2.0 PLAN FORMULATION

Plan formulation supports USACE water resources development missions. A systematic and repeatable planning approach ensures sound decision making. The Principles and Guidelines describe the process for Federal water resource studies requiring formulation of alternative plans contributing to Federal objectives. This chapter reviews the process to identify the TSP. The chapter also shows work performed after public and agency comments on the first draft of the report released in December 2013.

Plans or alternatives are composed of measures. Measures consist of features which are structural elements that require construction or assembly and/or activities which are nonstructural actions implemented to address planning objectives. Each feature and/or activity represents a measure that can be implemented to address planning objectives at a specific geographic site.

This study considered measures consistent with NED and NER objectives. All measures were evaluated and screened for capability to meet objectives and avoid constraints, for engineering and economic feasibility, and to maximize benefits provided over the 50 year period of analysis from 2025 - 2075. Measures that warranted continued consideration and met the success thresholds were assembled into alternative plans. In the evaluation process, each alternative plan was required to meet study-specific minimum standards and qualifying criteria in order to merit further consideration. Each plan was evaluated individually to determine whether it qualified for additional consideration.

Risk Reduction

The term "100-year level (1% ACE) of risk reduction," refers to a level of reduced risk of hurricane and storm surge and wave driven flooding that the project area has a 1 percent chance of experiencing each year. The 1 percent chance is based on the combined chances of a storm of a certain size and intensity following a certain track. Different combinations of size, intensity, and track could result in a 100-year surge event. The 50-year level (2% ACE) of risk reduction refers to a level of reduced risk of hurricane and storm surge and wave driven flooding that the project area has a 2 percent chance of experiencing each year. The 200-year level (0.5% ACE) of risk reduction refers to a level of reduced risk of hurricane and storm surge and wave driven flooding that the project area has a 0.5 percent chance of experiencing each year.

2.1 Goals and Objectives

Generally, the planning goals of the NED Plan are to reduce damages associated with hurricane and coastal storm surge flooding. The NED storm damage risk reduction plans were formulated to achieve NED principles and objectives. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the Nation.

The general planning goals of the NER Plan are to significantly and sustainably reduce land loss and coastal erosion in the study area, restore environmental conditions for the Chenier Plain ecosystem in SWC Louisiana, and evaluate a range of coastal restoration components to address a multitude of ecosystem problems. Plans were formulated to achieve NER principles and objectives. Contributions to NER are increases in the net quantity and/or quality of desired ecosystem resources, and are measured in the study area and nationwide.

The Project Delivery Team (PDT) developed the following planning objectives to apply to the entire study area over the 50-year planning horizon (2025-2075):

- NED Objective 1. Reduce the risk of damages and losses from hurricane and storm surge flooding.

- NER Objective 2. Manage tidal flows to improve drainage, and prevent salinity from exceeding 2 parts per thousand (ppt) for fresh marsh and 6 ppt for intermediate marsh.

- NER Objective 3. Increase wetland productivity in fresh and intermediate marshes to maintain function by reducing the time water levels exceed marsh surfaces.

- NER Objective 4. Reduce shoreline erosion and stabilize canal banks to protect adjacent wetlands.

- NER Objective 5. Restore landscapes, including marsh, shoreline, and cheniers to maintain their function as wildlife habitat and improve their ability to serve as protective barriers.

2.2 Constraints

The NED and NER plans are limited by the following constraints that are to be avoided or minimized:

- **Commercial navigation.** The Calcasieu and Sabine Ship Channels and the GIWW carry significant commercial navigation traffic. Measures that would cause shipping delays would result in negative NED impacts. In addition, the ability of authorized navigation projects to fulfill their purpose, such as the operation of locks along the GIWW, may be impacted by project features.
- **Federally listed threatened and endangered species and their critical habitats.** Construction schedules may be restricted due to threatened and endangered species such as piping plover, Gulf sturgeon, red-cockaded woodpecker, red knot, whooping crane, West Indian manatee, and several species of sea turtles.
- **Essential fish habitat (EFH), especially intertidal wetlands.** Conversion of one EFH type to another should be done without adversely impacting various fish species.
- **Historic and cultural resources.** Ninety-nine archeological sites were preliminarily identified within a one-mile buffer of the initial array of NED and NER alternatives, including one historic site ("Arcade Theater") listed on the NRHP and six potentially eligible prehistoric sites. Twelve historic properties listed on the NRHP have been identified within the one-mile buffer, including the Charpentier (Lake Charles) Historic District, as well as four eligible standing structures. Hundreds of standing structures in the area have a minimum age of 50 years and have not been assessed for eligibility.

2.3 Study Authorizations

2.3.1 NED Study Authorization

A survey of the coast of Louisiana in Cameron, Calcasieu, and Vermilion Parishes, with particular reference to the advisability of providing hurricane protection and storm damage reduction and related purposes, including the feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway was authorized by a Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2747, on December 7, 2005.

CEMVN initiated a Section 905(b) reconnaissance study in April 2006. NED alternatives to mitigate for hurricane-induced damages within Calcasieu, Cameron, and Vermilion Parishes were formulated through a series of planning meetings with the State of Louisiana, local parishes, and other stakeholders. The following three structural alternatives were initially determined to be economically justified with benefit/cost ratios greater than 1.0:

- Armored 12-foot earthen levee that allows for overtopping constructed along the GIWW alignment on the south side across Calcasieu, Cameron, and Vermilion parishes (height and alignment specified in the study resolution), with control structures constructed across waterways.
- Non-armored 12-foot earthen levee that allows for overtopping constructed along the north side of the GIWW providing storm damage risk reduction to the Lake Charles area.
- Non-armored 12-foot earthen levee that allows for overtopping constructed along the north side of the GIWW providing storm damage risk reduction to the Abbeville area.

2.3.2 NER Study Authorization

The 2004 Louisiana Coastal Area Ecosystem Restoration Study Report and Programmatic Environmental Impact Statement (2004 LCA Study) was developed to identify cost-effective, near-term (ten year implementation period) restoration features to reverse the degradation trend of the coastal ecosystem of Louisiana. The Near-Term Plan that resulted from the 2004 LCA Study focused on restoration strategies that would reintroduce historical flows of river water, nutrients, and sediments; restore hydrology to minimize

saltwater intrusion and maintain structural integrity of coastal ecosystems. The 2004 LCA Study identified critical projects, multiple programmatic authorizations, and ten additional required feasibility studies for LCA. The Report of the Chief of Engineers dated 31 January 2005 (2005 Chief's Report) approved the Near-Term Plan substantially in accordance with the 2004 LCA Study. Title VII of the Water Resources Development Act of 2007 (WRDA 2007) (Public Law 110-114) authorized an ecosystem restoration Program for the Louisiana Coastal Area substantially in accordance with the Near-Term Plan.

The Chenier Plain Freshwater Management and Allocation Reassessment Study (Chenier Plain Study), recommended in the 2005 Chief's Report was one of six large-scale restoration concepts that were purported to have the ability to "significantly restore environmental conditions that existed prior to large-scale alteration of the natural ecosystem" upon construction. WRDA 2007 authorizes fifteen near-term features to address critical restoration needs of coastal Louisiana, demonstration projects, a beneficial use of dredged material program, project modifications, and a science and technology program. Guidance provided by the Director of Civil Works on December 19, 2008 states that "*the coastal restoration components proposed as part of the LCA Chenier Plain study will be evaluated as part of the Southwest Coastal Louisiana feasibility study*".

A Feasibility Cost Share Agreement between USACE and the CPRAB as the non-Federal Sponsor was executed on January 14, 2009 for the study and analysis of the NED and NER study alternatives.

2.4 Prior Studies

Table 2-1 lists relevant reports and studies that were considered in the development of the NED and NER plans.

Table 2-1: Relevant prior studies, reports, programs, and projects for the SWC Louisiana feasibility study.

Prior Studies, Reports, Programs, and Water Projects	Parish	Potential Data Source	Consistency	Source of Measures
Planning Studies				
Coast 2050 Plan, 1999	All	✓	✓	
LCA, Louisiana Ecosystem Restoration Study, 2004	All	✓	✓	✓
Louisiana's Comprehensive Master Plan for a Sustainable Coast,-2012	All	✓	✓	✓
Louisiana Coastal Protection and Restoration (LACPR) Technical Report, 2009	All	✓	✓	✓
Calcasieu River Basin Feasibility Study (Draft)	Calcasieu	✓		
Calcasieu River and Pass, Louisiana, Dredged Material Management Plan and Supplemental EIS	Calcasieu, Cameron	✓	✓	✓
Federal Laws and Programs				
CWPPRA 1990	All	✓	✓	✓
USACE Continuing Authorities Program (WRDA Sec. 204), 1996	All			✓
CIAP, 2001 & 2005	All	✓		✓
Second Emergency Supplemental Appropriations Act to Meet the Immediate Needs Arising from the Consequences of Hurricane Katrina, 2005 (Public Law 109-062)	N/A	✓	✓	
Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act, 2006 (Public Law 109-148)	N/A	✓	✓	
State Laws and Programs				
Louisiana Coastal Wetlands Conservation, Restoration and Management Act, 1989	All		✓	
Act 8 of the Louisiana Legislature First Extraordinary Session of 2005	All	✓	✓	

Prior Studies, Reports, Programs, and Water Projects	Parish	Potential Data Source	Consistency	Source of Measures
Parish Coastal Wetlands Restoration Program (Christmas Tree Program)	All	✓		
Vegetation Planting Program	All	✓		
Ecosystem Restoration Projects By Funding Source				
CWPPRA Projects	All	✓	✓	
CIAP Projects	All	✓	✓	
State Projects	All	✓	✓	
WRDA Section 204/1135 Projects	All	✓	✓	
Federal Emergency Management Agency Projects	All	✓	✓	
Federal Navigation Projects				
Bayou Teche and Vermilion River	Vermilion		✓	
Freshwater Bayou and Freshwater Bayou Lock	Vermilion	✓	✓	
GIWW	All	✓	✓	
Calcasieu River, Pass and Bar Channel	Calcasieu, Cameron	✓	✓	
Mermentau River	Cameron	✓	✓	
Sabine-Neches Waterway	Calcasieu, Cameron	✓	✓	

2.5 NED Alternative Formulation

A broader description of the process used to formulate the initial array is captured in Table C-3 in Appendix C. Early modeling was performed to determine where flood damage potential exists in the study area. Figure 2-1 depicts red dots that represent structures within the structure inventory that are included within the 100-year floodplain and thus, are at risk of hurricane or storm-induced flood damages. At-risk structures are concentrated in several areas where levee systems could potentially reduce risk. The remainder of the study area (outside of Lake Charles, Delcambre, Abbeville, and Erath) is less densely populated and at-risk structures are dispersed over large areas. Therefore, nonstructural measures were considered for these less populated areas.

To assess the benefits of any structural, or nonstructural, alternative, measure, or feature the preventable physical damages to existing residential, commercial, industrial, and public buildings and facilities were considered. There are other physical damages, and/or disruptions, associated with broadly dispersed physical infrastructure and natural resources, that may be integral to economic sectors, such as oil and gas production (pipelines, production facilities,…) or agriculture (livestock, field crops,…). However, because no assurance of reduction in damage or associated loss of productivity can be achieved through the application of the measures and features available, these damages could not be included.

For this study, the structure inventory was supplemented with additional residential and non-residential properties that are expected to be placed in service in the future under without project conditions. These supplemental properties generically represent "future growth" in the study area with respect to economic assets. Flood plain regulations, mandated by the NFIP and executed through ordinances, building codes and permits, require that the first floor elevation of any new structure be placed at or above the base flood elevation as indicated by the corresponding FIRM. Therefore, while structures that are expected to be placed into service in the future are included in the structure inventory, their exposure to flood risk is significantly less than many structures found in the inventory under existing conditions.

The reduction in expected future damages to the physical facilities and industrial facilities in the study area, including oil and gas facilities, were considered as an NED benefit for BCR computations. To achieve this,

direct telephone contact was initiated to all of 71 owners/operators of industrial facilities in the area requesting information relating to the replacement cost of at-risk facility components and associated depth-percent-damage relationships. Of these 71 inquiries, 44 were successful in obtaining data that is required in the economic analysis. However, no information was provided by remaining 27 owners/operators. Lacking these data, no speculative estimation of depth-damage relationships to these facilities were made and as a result, the structure inventory used to evaluate damages and benefits for levee plans does not include these facilities.

Plan Development Strategies. Prior to developing specific measures and features for alternative formulation, the PDT identified two broad categories to address study goals: a comprehensive levee plan and a comprehensive nonstructural plan. The reconnaissance report recommendation (12-foot levee along the GIWW) was also used as a starting point to achieve study objectives.

- **Armored 12-foot levee along the GIWW (Reconnaissance Report Recommendation).** Study authority requires assessing the "feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway." This 122-mile levee was determined to be marginally justified in the 2007 reconnaissance report. Nonstructural measures would be applied to communities south of the GIWW, including Cameron, Hackberry, Holly Beach, Creole, Grand Chenier, Pecan Island, and Intracoastal City. This plan is not included in the 2012 State of Louisiana Comprehensive Master Plan for a Sustainable Coast (State Master Plan).

- **Comprehensive Levee Plan.** Individual levees would be built around the largest population centers, and nonstructural measures would be applied in all other areas. Levees could be located around the areas of Lake Charles, Abbeville (including Erath and Delcambre), Kaplan, and Gueydan. The Lake Charles metropolitan area is the largest urban center with a population of approximately 194,000 (U.S. Census, 2009). From west to east, the communities of Gueydan, Kaplan, Abbeville, Erath, and Delcambre are located in northern Vermilion Parish along Highway 14 and have estimated populations of 1,600, 5,200, 12,300, 2,200, and 2,200, respectively (U.S. Census, 2010). The State Master Plan includes plans for levees in the greater Lake Charles and Abbeville areas. Plans for levees around Kaplan and Gueydan are included in the LACPR study.

- **Comprehensive Nonstructural Plan.** Nonstructural measures were considered as alternatives that could be implemented in the entire study. Owners of eligible residential and commercial structures (including public buildings but excluding warehouses and industrial facilities) would participate in implementing measures such as structure elevating, flood proofing, and berms. Property acquisition may also be considered if circumstances warrant.

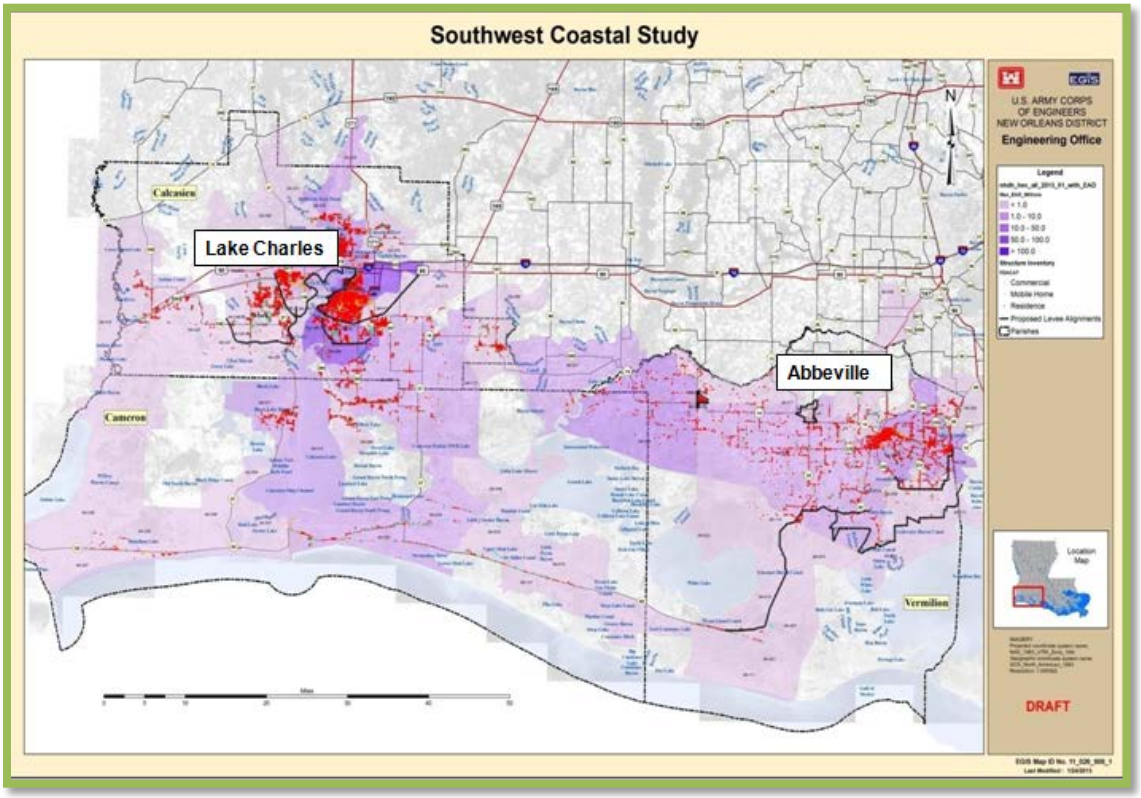

Figure 2-1: Structure inventory and density.

2.5.1 NED Measures (*NEPA Required)

Ten NED measures were developed from various sources including the PDT and the State Master Plan.

Table 2-2: Potential NED measures.

Structural Measures	Nonstructural Measures
Earthen Levees	Elevation-in-Place
Floodgates	Property Acquisition
Floodwalls	Flood proofing
Pumps	Berms
Highway Armoring	Floodplain Management Plans, Public Information Campaigns, local government building and zoning code requirements, developmental controls, restrictive covenants, etc.

Structural and nonstructural measures were evaluated to form comprehensive risk reduction plans for the entire study area. North of the GIWW, combinations of structural and nonstructural measures were based on existing plans (i.e., Southwest Coastal Reconnaissance Study, LACPR, State Master Plan, and the Vermilion Parish Hurricane Protection Plan). South of the GIWW, structural plans were not technically feasible because of broadly dispersed (rural) populations.

2.5.2 Initial Array of NED Alternative Plans (*NEPA Required)

The following 15 hurricane and storm damage risk reduction alternatives were identified for further analysis:

Table 2-3: NED initial array of alternatives.

Independent Variations	
Armored 12-Foot Levee Along the Length of the GIWW	
Gueydan Ring Levee	
Kaplan Ring Levee	
Louisiana Highway 330/82 Armoring	
Nonstructural Measures	
Lake Charles Levee Variations	**Abbeville Levee Variations**
Lake Charles – Southern (east and west)	Abbeville Marsh/Upland Interface
Lake Charles – Southern/Eastern only	Abbeville along GIWW
Lake Charles – Southern/Western only	Abbeville along LA Highway 330
Lake Charles – Northern (east and west)	Abbeville (shortened variation) – Excludes Erath and Delcambre
Lake Charles – Northern (east only)	
Lake Charles – Northern (west only)	

The PDT used the following assumptions to create a screening process for the initial array of the 15 NED alternatives.

- Ninety hydrologic reaches characterized by unique relationships between storm surge elevations and frequencies were identified. Of these 90 reaches, only 63 were shown to include economic assets that were subject to inundation damages.
- An inventory of structure values, types, and first floor elevations was compiled for all residential and non-residential structures in the study area which totaled approximately of 52,000 structures. These included industrial structures for which owners/operators provided information with respect to the vulnerability of damageable property. Warehouses were considered at this stage for the structural plans only, but were included in a subsequent detailed analysis of nonstructural plans.
- A range of low and high costs were developed for the structural features considered.
- Without-action damage estimates were developed and multiplied by a rule of thumb based on the reciprocal of interest and amortization (in this case 20) and used as a surrogate for potential benefits. These values were then used to determine the level of construction costs that could be supported. Stage-probability curves were calculated using HEC-RAS (for rainfall) and ADCIRC (surge) model results. They represent 2012 existing conditions.
- An estimating approach was used to determine the potential first construction cost that could be supported by the potential project benefits expressed as an expected annual value. The amortization factor for a Federal discount rate of 3.5 percent is 0.04263. The inverse of that number (23.5) was used as a multiplying factor to develop the initial estimate. However, this figure is a rough estimate of total project costs that could be supported, rather than project first costs. The PDT rounded the factor to 20.0 to account for additional non-construction components of total project costs (interest during construction, O&M, engineering and design, and supervision and administration costs).
- The difference between the benefits and costs represents net benefits.
- Simplifying assumptions were made:
  - No induced damages from flooding outside levees. No damages from waves.
  - Structural alternatives would eliminate all potential surge or rainfall damages for events between 25 and 200 years, which represent events dominated by storm rather than predominantly rainfall flooding. Net benefits less than zero were used to screen alignments.
- Intermediate RSLR was used for future conditions.
- Under without-project conditions, structures at or below the 10-year stage are considered to be repetitively-flooded properties in the evaluation of both structural and nonstructural plans. Therefore, the structure inventory used in the economic analysis (for both structural and nonstructural plans) reset these properties to an elevation beyond the limits of the 100-year floodplain.

- For levee plans that provide flood risk reduction up to the base flood elevation for a 100-year event (1% ACE), few if any benefits would accrue to these structures. Therefore, their addition to the structure inventory has a minor impact on BCR estimates.

2.5.2.1 Initial NED Alternative Plan Screening Considerations

Results of how the 15 initial NED alternatives were assessed and eliminated are presented in Table 2-4. The complete set of structural plans evaluated at this level of screening is described in Table C-4 of Appendix C.

Table 2-4: NED initial screening.

Feature Name (ID)	Levee Length (miles)	Best Estimate Benefits x 20 in mil $[1]	"Low Cost Scenario" Levee + Pumps in mil $[2, 3]	"High Cost Scenario" Levee + Pumps in mil $[4]	Are best estimate benefits x 20 greater than "Low" costs?	Are best estimate benefits x 20 greater than "High" costs?	Screening Decision
Armored 12-ft Levee along the GIWW (per study authority and Recon Alt S-1)	122	1,835	3,372	4,714	No	No	Eliminated; not enough benefits (once repetitive damages removed) to justify structural solution cost.
Gueydan Ring Levee	6	8	120	180	No	No	Eliminated; damages would have to increase by orders of magnitude to justify structural solution cost.
Kaplan Ring Levee	11	0.7	215	325	No	No	Eliminated; damages would have to increase by orders of magnitude to justify structural solution cost.
Louisiana Highway 333/82 Armoring	29	N/A	551	841	N/A	N/A	Eliminated; not enough damages to justify structural solution cost
Abbeville Levee along the Marsh/Upland Interface	33	441	990	1,320	No	No	Eliminated; not enough damages to justify structural solution cost[5]
Abbeville Levee along Highway 330	13	336	275	405	Yes	No	Although benefits are less than high cost estimates, they are within a margin of error. Consider further for reformulation.

1: Multiplication by "20" represents the amortization factor over 50 years based on existing and future-without project expected annual flood damage (EAD). First screening used unadjusted inventory; rainfall, and frequent and repetitive damages were not removed. Damages didn't account for industrial structures or future RSLR. Second screening refined the damages to eliminate frequent, repetitive damages. Based on the results from the Morganza to the Gulf of Mexico study, adjustment for RSLR estimated that damages would increase by 50% over existing damages.

2: "Low" levee cost used $21,000,000/mile armored and $19,000,000/mile unarmored (grass only). The unarmored cost is based on indexing the LACPR estimates to current levels. Assuming the existing ground elevation is +5-feet, a 12-foot levee elevation equals +17-feet; with contingency, the cost per mile would be about $15,500,000 for the levee only. It would be around $18,600,000 including engineering and design, and supervision and administration (rounded to $19,000,000 per mile). Additional cost of $2,000,000 per mile for armoring.

3: Pumping costs for the alternatives based on what was developed for LACPR. Pumping costs for GIWW alignment based on the sum of the largest Lake Charles and Abbeville ring levees.

Other studies: Morganza 35-yr levees cost over $60,000,000 per mile for 10- to 20-ft levees (total cost including structures, mitigation, E&D, S&A, etc). Morganza to the Gulf of Mexico 100-yr levees costs over $100,000,000 per mile for 15- to 26.5-ft levees (total cost including structures, mitigation, E&D, S&A, etc.). Southwest Coastal Reconnaissance Study used $14,000,000 to $20,000,000 per mile but these values were considered extremely low. After initial screening, 10 hurricane and storm surge damage reduction alternatives remained.

4: "High" levee cost used $32,000,000 per mile armored; $29,000,000 per mile un-armored (grass only). High costs based on 50% increase over Low costs rounded up to nearest million.

5: Although this particular alternative was screened, its value as a set of smaller individual levees was evaluated for Abbeville and Delcambre. The incrementalized alternatives were made a part of the focused array.

The screening removed all alternatives with net benefits of less than zero including the following:

- **Armored 12-foot levee along the GIWW:** Eliminated from further consideration because potential benefits do not justify estimated costs.
- **Kaplan and Gueydan ring levees:** Eliminated from further consideration. Benefits were an order of magnitude less than the costs and as a result only nonstructural measures were evaluated.
- **Louisiana Highway 333/82 armoring:** Eliminated from further consideration. Since NED benefits are unclear and the highway is maintained by the Louisiana Department of Transportation and Development, it may be more cost effective for the State to construct this measure.
- **Abbeville Levee along the Marsh/Upland Interface:** Eliminated from further consideration because potential benefits do not justify estimated costs.

2.5.3 Focused Array of NED Alternative Plans (*NEPA Required)

The initial screening left 10 alternatives (the focused array) that warranted additional evaluation. (see Table 2-5) A full description of all features and screening is available in Appendix C.

Table 2-5: Initial alternatives that comprise the NED focused array

Independent Variations
Nonstructural Measures
Abbeville Levee Variations
Abbeville along GIWW
Abbeville along LA Hwy 330
Abbeville (shortened variation) – Excludes Erath and Delcambre
Lake Charles Levee Variations
Lake Charles – Southern (east and west)
Lake Charles – Southern/Eastern only
Lake Charles – Southern/Western only
Lake Charles – Northern (east and west)
Lake Charles – Northern (east only)
Lake Charles – Northern (west only)

2.5.3.1 Evaluation of Focused Array & Refinement of Array to 6 NED Structural Alternatives

The PDT assessed the focused array of alternatives and as a result, some levee alignments were incrementalized and developed into new alternatives. Although some Abbeville structural alternatives have little to zero marginal benefits, the PDT considered whether a set of smaller individual levees for Abbeville and Delcambre could provide a more cost-effective solution. Since levees around rural areas tend to drive down benefits significantly, the PDT developed smaller, incrementalized alternatives that showed the potential for higher benefits and lower costs for the more densely populated areas. Additionally, since a structural solution for Abbeville is included in the State Master Plan, new configurations of the Abbeville levee were developed for additional analysis.

Benefits for the east Lake Charles levees outweigh costs, but for the western Lake Charles levees, costs outweigh benefits. As a combined set of structural features, the east and west Lake Charles levees only had marginal benefits to justify costs, but since the PDT felt new levee alignments could be drawn to better focus on more densely populated areas and since a 500-year structural solution for Lake Charles is included in the State Master Plan, reconfigured Lake Charles west levees were carried forward.

These steps allowed the PDT to identify levee alignments that would more precisely target populated areas adjacent to Lake Charles and Abbeville because only the largest population centers had the potential benefit-cost ratio to support structural measures. Three alignments were drawn at a small scale, using existing USACE maps and Google Maps, to protect major residential neighborhoods, while minimizing crossings that would result in major real estate, relocation, and other costs such as pipelines, major roadways, and industrial

areas. The alignments depicted in the graphics below comprise the focused array (along with no action and the nonstructural plan) and were carried forward for additional analysis. Figures 2-2, 2-3, and 2-4 show the locations of the proposed alignments with respect to Lake Charles, Abbeville, Delcambre, and Erath.

The focused array thus consists of the alternative plans listed below. Each structural plan was evaluated at three levels of risk reduction [50-year (2% ACE), 100-year (1% ACE), 200-year (0.5% ACE) levels] along the same alignment during these comparisons.

Plan 0: No Action
Plan 1: Lake Charles Eastbank Levee
Plan 2: Lake Charles Westbank/Sulphur Extended Levee
Plan 3: Lake Charles Westbank/Sulphur South Levee
Plan 4: Delcambre/Erath Levee
Plan 5: Abbeville Levee
Plan 6: Abbeville to Delcambre Along Hwy 330 Levee
Plan 7: Nonstructural Measures

2.5.4 Evaluation of 6 NED Structural Alternative Plans

Ninety hydrologic reaches throughout the study area were developed and characterized by unique relationships between storm surge elevations and frequency. With-project damages were developed for the base and future conditions utilizing existing data, current and future without-project damages, and parametric costs. The alternatives were screened based on the 50 year (2% ACE), 100 year (1% ACE), and 200 year (0.5% ACE) levels of risk reduction.

Using the damage probability relationship from the HEC-FDA model for the six structural alternatives in the reaches receiving damage, it was estimated that a 50 year (2% ACE) project, would eliminate damages for the 25 and 50 year events. The 100 year (1% ACE) project would eliminate damages for the 25, 50 and 100 year events and the 200 year (0.5% ACE) project would eliminate damages for the 25, 50, 100 and 200 year events. The six alternatives would not eliminate damages from rainfall for more frequent events (1 and 10 year events) because limited topographic relief results in rainfall driven flooding that structural protection measure cannot prevent at higher frequency events.

A percentage was applied to the overall benefits by reach for each of the six structural alternatives to reflect the estimated percentage of the total structures in a reach that are receiving risk reduction from each alternative. For example, approximately 40 percent of the residential and non-residential structures in reach XA-305 lie behind the proposed levee alignment. Therefore, the estimated total benefits calculated for that reach are multiplied by 40 percent to determine the benefits for the Abbeville to Delcambre alternative for reach XA-305. This methodology was applied to all proposed alternatives.

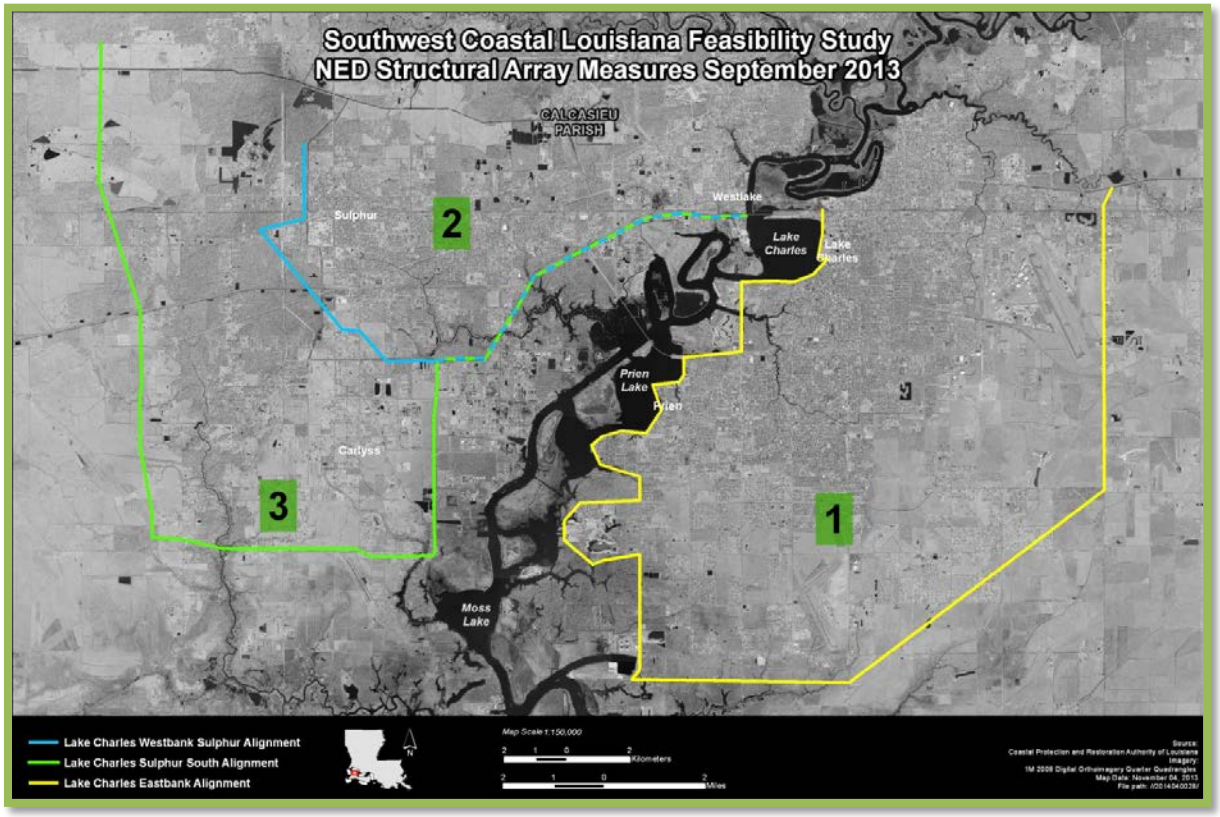

Figure 2-2: Lake Charles conceptual structural alignments.

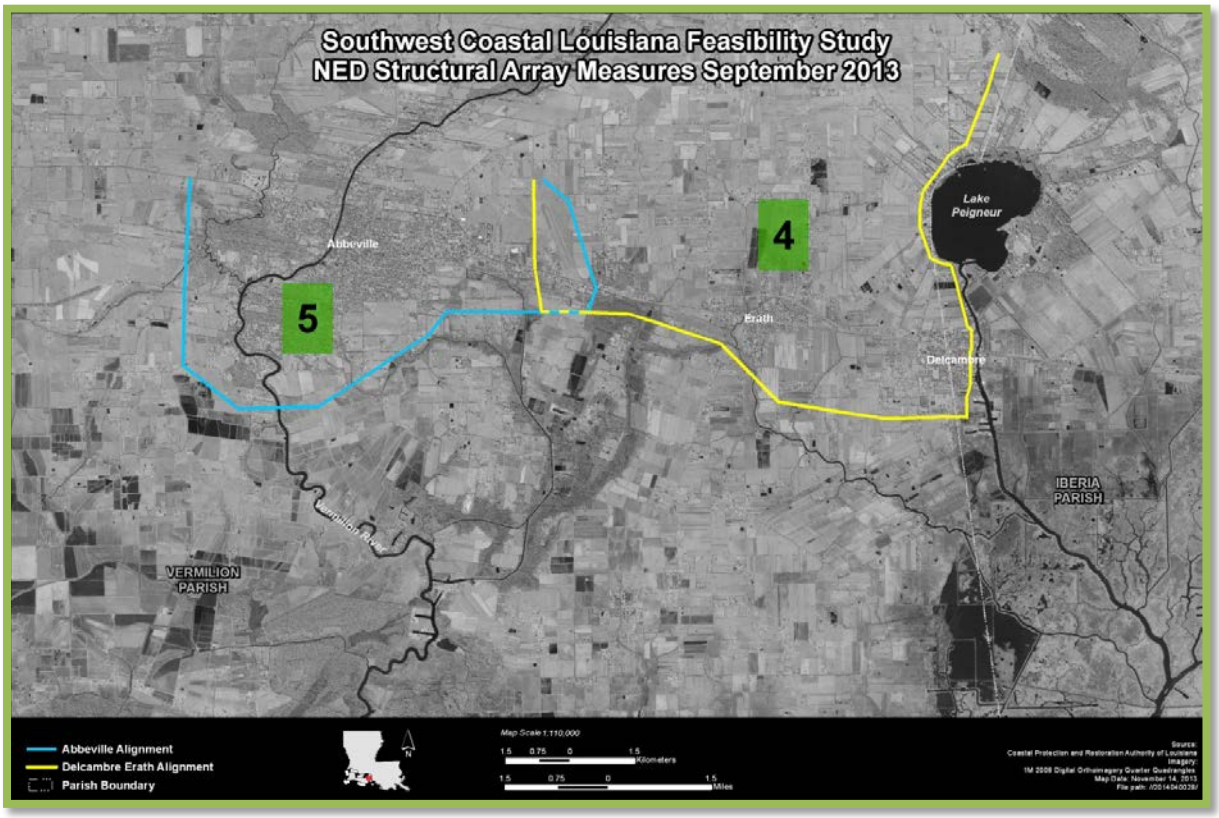

Figure 2-3: Abbeville, Delcambre, and Erath conceptual structural alignments.

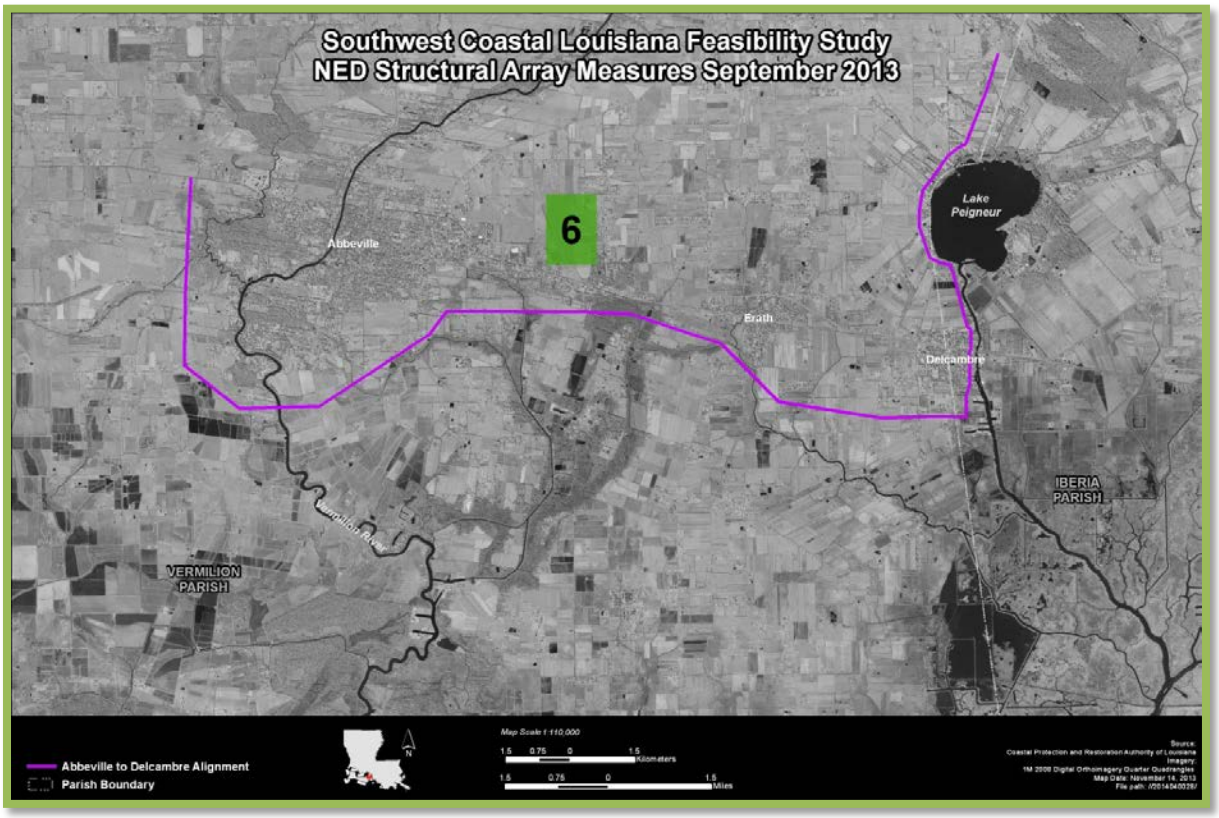

Figure 2-4: Abbeville to Delcambre combined conceptual structural alignment.

2.5.4.1 Economic Analysis of NED Structural Alternative Plans

A benefit/cost analysis was conducted to evaluate the economic feasibility of each of the structural plans. Expected annual benefits for 2025 and 2075 were converted to an equivalent annual value using the previous FY14 Federal interest rate, 3.5 percent, and a 50-year period of analysis. Total cost and estimated annual costs for the project alternatives included the construction costs, and operation and maintenance costs for the three levels of risk reduction. Construction costs, along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period. For the purposes of this study, construction was assumed to begin in 2017 and continue through 2024 with additional levee lifts (to maintain levee height due to sinking and subsidence) beginning in 2067 and construction ending six to seven years later. The first levee lifts would be overbuilt and allowed to settle for several years before the latter levee lift is added for each alternative. Later levee lifts would account for the relative sea level rise and subsidence that is projected to occur throughout the period of analysis.

Tables 2-6 through 2-8 show the first construction costs; average annual costs, average annual benefits; benefit/cost ratios; and net benefits for each alternative in the focused array. As shown in the tables, the Lake Charles Eastbank alternative was the only one with a justified benefit/cost ratio (value >1.0). The Lake Charles Eastbank alternative was justified at each level of protection. The highest net benefits were for the Lake Charles Eastbank alternative at the 100 year (1% ACE) level of protection.

Table 2-6: Economic analysis of alternatives with 50-year (2% ACE) level risk reduction.

Alternatives	First Costs (in Mil $)	Average Annual Costs (in Mil $)	Average Annual Benefits (in Mil $)	Benefit/Cost Ratio	Net Benefits (in Mil $)
Plan 1: Lake Charles Eastbank*	779.4	35.8	37.6	1.05	1.9
Plan 2: Lake Charles Westbank - Sulphur Extended	142.8	6.5	1.4	0.22	-5.0
Plan 3: Lake Charles Westbank - Sulphur South	456.3	20.7	3.0	0.14	-17.7
Plan 4: Delcambre/Erath	359.4	15.5	11.1	0.72	-4.4
Plan 5: Abbeville	286.0	12.9	2.6	0.20	-10.3
Plan 6: Abbeville to Delcambre Along Hwy 330	628.5	27.8	19.4	0.70	-8.4

Table 2-7: Economic analysis of alternatives with 100-year (1% ACE) level risk reduction.

Alternatives	First Costs (Mil $)	Average Annual Costs (Mil $)	Average Annual Benefits (Mil $)	Benefit/Cost Ratio	Net Benefits (Mil $)
Plan 1: Lake Charles Eastbank*	979.1	43.9	50.7	1.16	6.8
Plan 2: Lake Charles Westbank Sulphur Extended	199.3	8.6	3.3	0.39	-5.2
Plan 3: Lake Charles Westbank Sulphur South	629.1	27.6	7.2	0.26	-20.4
Plan 4: Delcambre/Erath	470.8	20.3	14.5	0.72	-5.8
Plan 5: Abbeville	344.1	15.4	7.2	0.47	-8.2
Plan 6: Abbeville to Delcambre Along Hwy 330	784.2	34.4	27.1	0.79	-7.3

Table 2-8: Economic analysis of alternatives with 200-year (0.5% ACE) level risk reduction.

Alternatives	First Costs (Mil $)	Average Annual Costs (Mil $)	Average Annual Benefits (Mil $)	Benefit/Cost Ratio	Net Benefits (Mil $)
Plan 1: Lake Charles Eastbank*	1,224.1	54.2	61.1	1.13	6.9
Plan 2: Lake Charles Westbank Sulphur Extended	327.1	13.9	5.5	0.39	-8.4
Plan 3: Lake Charles Westbank Sulphur South	883.9	38	12.5	0.33	-25.5
Plan 4: Delcambre/Erath	589.5	25.4	17	0.67	-8.5
Plan 5: Abbeville	447.7	19.9	9.7	0.49	-10.2
Plan 6: Abbeville to Delcambre Along Hwy 330	1,000	43.6	32.5	0.75	-11.1

* Although preliminary assessments identified a positive benefit/cost ratio for this alignment, further analysis described in section 2.5.7 revealed a negative benefit/cost ratio.

2.5.5 Nonstructural Plan Evaluation

The following nonstructural measures were evaluated:

- Elevation of residential structures to predicted 2075, 100-year base flood elevation unless the required elevation is greater than a maximum of 13 feet above ground level.
- Acquisition/buyout of residential structures that would require elevation over 13. Property owners would receive fair market value for the property acquired.
- Flood proofing of non-residential and public structures (excluding industrial buildings and warehouses) for flood depths not greater than three feet above the adjacent ground

2.5.6 Economic Analysis of NED Nonstructural Alternative Plans (Initial Draft Report)

The total number of structures inventoried in 2012 (defined by the footprint of the 2075, 500-year (0.05% ACE) floodplain) is approximately 52,000. The number of expected at-risk structures in the 100-year (1% ACE) floodplain, in the base-year 2025 including those captured by RSLR, totaled 23,161 residential, commercial, and public buildings (but excluding warehouses and industrial buildings) with a First Floor Elevation (FFE) below the 100-year stage.

Nonstructural plans were initially evaluated using 90 hydrologic reaches within the study area as the unit of analysis. Structures were included in the inventory if their FFE fell below the expected 2075, 100-year (1% ACE) floodplain and evaluated for potential damages over the 50-year period of analysis. Benefits and costs were calculated on a reach-by-reach basis. Economic justification of each reach was determined by a comparison of average annual benefits to average annual costs. Reaches with a benefit/cost ratio greater than 1.0 were carried forward for additional consideration. Justification was determined by comparing expected annual benefits to expected annual costs. Net benefits were calculated by subtracting the expected annual costs from expected annual benefits. The initial analysis found that 11 of 90 reaches were economically justified as shown in Figure 2-5. Table 2-9 identifies costs, benefits, and benefit/cost ratios for each of the justified reaches. The data extracted from the justified reaches demonstrates the Federal interest in a nonstructural plan and provides definition of the potential magnitude of the plan.

Analysis found that 11 of the 90 hydrologic reaches had a benefit/cost ratio of 1.0 or greater and were economically justified. Ratios for the other 79 reaches fall at or below unity. The combined expected annual benefits for the justified reaches, hereafter referred to as the **Nonstructural - Justified Reaches Plan (Plan 7)**, was estimated at $20.67 million assuming 100% property owner participation, the total cost for implementing a nonstructural alternative based solely on the justified reaches is approximately $388 million. The corresponding average annual cost is approximately $16.5 million; with net benefits of $4.17 million resulting in a benefit/cost ratio of 1.25. As a result, benefits and costs were calculated on a reach-by-reach basis. The results of this screening analysis demonstrated that there is a Federal interest in implementing nonstructural alternatives which warranted a more focused analysis to consider only those structures within the 2075, 100-year floodplain. From this effort, Plan 8 evolved.

This more focused evaluation of the economic feasibility of nonstructural measures was also conducted for all structures within the 2075, 100-year (1% ACE) floodplain, irrespective of their location within a reach. This assessment is referred to as the **Nonstructural - 100-year Floodplain Plan (Plan 8)**. The total expected annual benefits for addressing all of the structures within the 2075, 100-year (1% ACE) floodplain are $74.6 million. The total cost for implementing the nonstructural alternative throughout the 2075, 100-year (1% ACE) floodplain is approximately $3.2 billion. The corresponding average annual cost is approximately $138.2 million. After evaluating the entire 90 reach study area, (Plan 8), it was determined that the benefit/cost ratio for addressing all structures within the 100-year floodplain was 0.54.

Table 2-9: Initially justified nonstructural reaches.

Reach	Total Cost (in Th $)	Number of Structures in Reach	Average Annual Cost (in Th $)	Equivalent Annual Benefits (in Th $)	Benefit/Cost Ratio	Net Benefits (in Th $)
SA-033-RL(76)	8,466	77	361	369	1.01	3
SA-034(79)	9,591	122	409	622	1.51	208
SA-048(106)	34,647	389	1,477	2,022	1.36	532
SA-070-S(139)	13,687	134	583	934	1.59	345
SA-091(187)	12,896	169	550	1,362	2.46	802
SA-112(250)	10,177	148	434	573	1.31	132
XA-306(280)	296,306	2,860	12,632	14,691	1.15	1,958
XA-324(337)	1,232	7	53	66	1.26	13
XA-327(346)	114	1	5	8	1.66	3
XA-336(373)	583	5	25	131	5.22	105
XA-341(388)	341	3	15	36	2.44	21

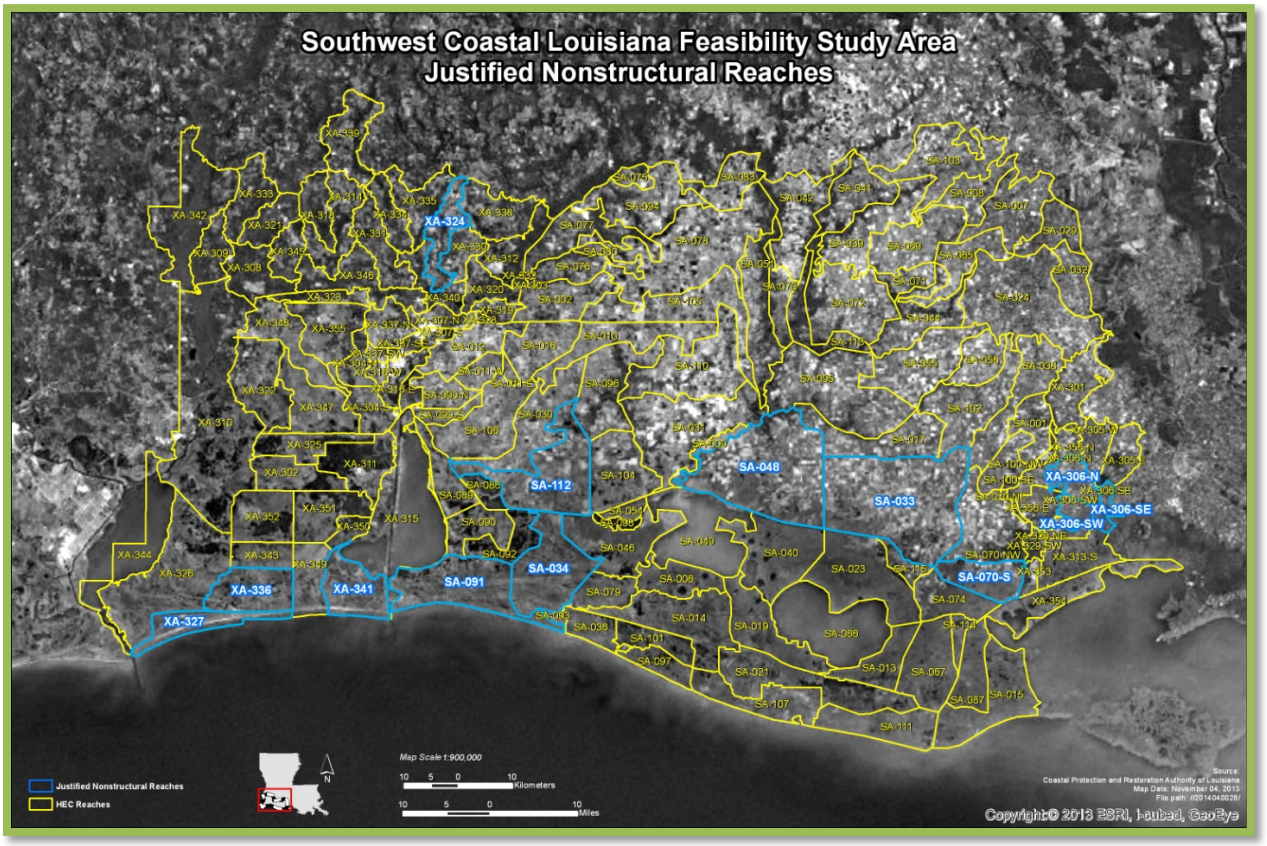

Figure 2-5: Nonstructural reaches with justified benefit/cost ratios.

2.5.7 Net Benefits of the Focused Array of NED Alternative Plans

See Table 2-10 for a summary of the net benefits of the structural alternatives, as well as the benefits for the 100-year level of risk reduction nonstructural alternatives. The two nonstructural plans considered any

structure with a FFE below the 2075 100-year (1% ACE) stage. This was done to correspond with FEMA regulations that require new development to FFE higher than the 100 year (1% ACE) floodplain.

Table 2-10: Net NED benefits.

Alternatives	50 year (Mil $)	100 year (Mil $)	200 year (Mil $)
Plan 1: Lake Charles Eastbank#	1.9	6.8	6.9
Plan 2: Lake Charles Westbank Sulphur Extended	-5.0	-5.2	-8.4
Plan 3: Lake Charles Westbank Sulphur South	-17.7	-20.4	-25.5
Plan 4: Delcambre/Erath	-4.4	-5.8	-8.5
Plan 5: Abbeville to Delcambre	-8.4	-7.3	-11.1
Plan 6: Abbeville	-10.3	-8.2	-10.2
Plan 7: Nonstructural -Justified Reaches Plan	N/A	4.3	N/A
Plan 8: Nonstructural - 100-Year Floodplain Plan	N/A	-64.3	N/A

See additional considerations in the following section

Additional Structural Evaluation

The assessment of economic feasibility for six independent structural measures was conducted in the focused array analysis. Initial results of the assessment show that only one structural alternative economically justified: the Lake Charles Eastbank Levee Alternative, Plan 1. However, at the time of the assessment an estimate of mitigation costs (costs each structural alternative must account for due to unavoidable habitat impacts) had not been calculated for the levee alternatives. With mitigation costs of approximately $100,000,000 included for each alternative, the 100-year (1% ACE) level of risk reduction yielded a benefit/cost ratio of 1.01 and the 200-year (0.5% ACE) level of risk reduction yielded a benefit/cost ratio of 1.04 (adding the mitigation costs made the 50-year (2% ACE) level of risk reduction not economically justified).

In addition, prior to the completion of the initial draft report additional assessment of the 100-year (1% ACE) and 200-year (0.5% ACE) Lake Charles levee alignments was conducted to evaluate the potential for any other viable levee design scales (75-year (1.5% ACE), 125-year (0.8% ACE). This additional investigation exposed an anomaly in the structure inventory database. The structure inventory used to calculate benefits for this alternative was modified to adjust the first-floor elevation for a single commercial structure that was incorrectly placed within the 100-year (1% ACE) floodplain. This structure would otherwise account for an unusually high percentage of damages and benefits in initial evaluations. Once this adjustment was completed, the benefit/cost ratio for Plan 1 fell to 0.61 for the 100-year (1% ACE) level of risk reduction and to 0.30 for the 200-year (0.5% ACE) level of risk reduction. As a result of this additional evaluation, none of the structural levee alignments were found to be economically justified and none were carried into the final array.

2.5.8 Final Array of NED Alternative Plans Presented in the Initial Draft Report

The evaluation of the focused array determined that the most cost-effective solution to reduce hurricane and storm surge flood-risk within the study area is through nonstructural measures. Two alternative nonstructural plans plus the No Action Plan were carried forward for the NED final array. One was Plan 7, Nonstructural - Justified Reaches Plan, based on only the 11 economically justified reaches. A second, designated Plan 8, Nonstructural - 100-year Floodplain Plan, was considered by the team to represent a potentially reasonable alternative based on the incremental presence of relatively high flood risk structures (100-Year floodplain) that exist throughout the study area irrespective of location within a defined reach. The results of the initial analysis demonstrated that there is a Federal interest in implementing nonstructural alternatives and also indicated that a more focused analysis may produce an optimization of the achievable net benefits.

2.5.9 Summary of Accounts & Comparison of Alternative Plans in the Initial Draft Report

To facilitate alternatives evaluation and comparison of the alternatives, the 1983 Principles and Guidelines lay out four Federal Accounts that are used to assess the effects of alternatives. The accounts are National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

- The NED account displays changes in the economic value of the national output of goods and services. The 1983 Principles and Guidelines require the identification of an NED plan from among the alternatives.
- The EQ account displays non-monetary effects on significant natural and cultural resources.
- The RED account registers changes in the distribution of economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
- The OSE account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

2.5.10 Final Array of NED Plans As Presented in the Initial Draft Report

Plan 0: **No Action.** No NED benefits would be associated with the No Action alternative. There would continue to be adverse impacts to the EQ account as salinity levels increase in the area and existing wetlands continue to degrade and disappear. These impacts will continue to affect residents and infrastructure through the encroachment of open water (OSE). Reducing the protective wetlands in the area could have negative effects to RED by impacting major oil refineries, shipping channels, and industrial uses in the study area.

Plan 7: **Nonstructural - Justified Reaches Plan (TSP).** This plan provides positive net NED benefits and has a positive benefit/cost ratio. Impacts to EQ would be minimal as no significant features would be constructed and structures to be elevated, acquired, or flood proofed already exist. Effects to RED would be beneficial due to the implementation of risk reduction features and the resulting reduction in risk of hurricane and storm-surge related damages to those structures located within the identified reaches which ultimately benefit by the risk reduction measures. Regarding OSE, depending on the manner in which the nonstructural measures would be implemented, there could be an improvement in the area of social vulnerability for populations benefiting from the nonstructural measures. That notwithstanding, the potential for inundation and other storm-related damages will continue unabated for structures that are not addressed under this alternative. Implementing this alternative would not address the most populated communities.

Plan 8: **Nonstructural - 100-Year Floodplain Plan.** This plan provides negative net NED benefits and has a negative benefit/cost ratio. However, it is recognized that there are significant individual increments of positive net benefit throughout the study area. Impacts to EQ would be minimal as no significant features would be built and structures to be elevated, acquired, or flood proofed already exist. Effects to RED would be beneficial due to the implementation of risk reduction features and the resulting reduction in risk of hurricane and storm-surge related damages to those structures benefiting by the risk reduction measures. Regarding OSE, depending on the manner in which the nonstructural measures would be implemented, there could be an improvement in the area of social vulnerability for the larger population that would benefit from the nonstructural measures. That notwithstanding, the potential for inundation and other storm-related damages will continue unabated for structures that are not addressed under this alternative. This alternative does address the most populated communities.

2.5.11 Identification of NED TSP (Plan 7) Presented in the Initial Draft Report

The preliminary NED TSP in the initial draft report was Plan 7 (Nonstructural Justified Reaches). Plan 7 and Plan 8 were both based on structures located within the 2075, 100-year (1% ACE) floodplain and were carried forward, however only Plan 7 was economically justified. Plan 7 applied nonstructural measures (i.e.

structure raising, flood-proofing, and property buy-outs) to structures within the 11 justified reaches and consisted of elevation of existing residential structures or acquisition of properties that require significant elevation, and flood proofing measures for non-residential structures for at-risk properties within the 2075, 100-year (1% ACE) floodplain. The initial basis for the selection of Plan 7 as the original TSP was the number of structures and cost identified in the 11 justified reaches. The preliminary estimated cost of Plan 7 as presented in the initial draft report is $388,000,000 for nonstructural measures benefiting 3,915 structures.

2.6 Nonstructural Plan Evaluation Conducted after Release of the Initial Draft Report

After the release and receipt of comments on the December 2013 Initial Draft Report, structures in the 0-10-year floodplain were added to the structure inventory and additional economic calculations were performed to determine whether the addition of these repetitive flood risk structures resulted in a positive net NED benefits and has a positive benefit/cost ratio. This NED Plan is referred to as the "Nonstructural 0-25 Year Floodplain Plan." Although the NED plan with the greatest net benefits had been identified as a nonstructural option, the economic model was rerun using this updated inventory to determine whether this inventory could support a justified structural alternative. The best performing structural alternative, Plan 1, still failed to demonstrate a positive benefit/cost ratio. The benefit/cost ratio for this plan was determined to be 0.84 for the 50-year (2% ACE) plan; 0.996 for the 100-year (1% ACE) plan; and 0.93 for the 200-year (0.5% ACE) plan.

The revised evaluation of nonstructural measures consisted of evaluating every structure in the revised inventory, with a FFE below the 100-year stage for water surface elevations (WSEs) prevailing in the year 2025 rather than the year 2075. Warehouses were also added to the structure inventory for benefit evaluation where small berms of floodwalls less than 6 ft in height represented the most appropriate nonstructural measure to reduce flood risk. While RSLR is expected to raise the 100-year stage throughout the 50 year period of analysis and bring the FFEs for other structures into the 100-year floodplain, economic benefits for implementing such plans (for structures forecast to be at risk by 2075 in the 2025 base year) are heavily discounted and were generally found to lack economic justification.

Next, using the inventory of structures with FFEs identified within the 2025 100-year floodplain, the nonstructural analysis was stratified on the basis of flood zones. Structures located in between the 0-25-year flood zones were deemed to be exposed to the highest level of flood risk and were considered the first increment. The second increment consists of structures with FFEs higher than the 25-year stage, but lower than or equal to the 50-year stage. The third increment encompasses all remaining structures located within the 100-year floodplain. This analysis created refined incremental variations of the previously assessed Plan 8 which was now divided into separate flood zone benefit categories.

The economic appendix (Appendix D) describes the specific methodology used to evaluate specific increments of the new nonstructural TSP ("Modified Plan 8") within the 100-year floodplain so that net benefits could be optimized. These increments differentiated structures between the 0-25-year; 25-50-year; and 50-100-year floodplains.

Table 2-11 shows the results of this analysis. Net benefits remain positive for the first two increments (0-25 year and 25-50 year) and support the Federal interest for subsequent implementation. In contrast, net benefits for the 50-100-year increment are negative due to the fact that properties within these flood plains do not suffer the same magnitude of inundation as structures grouped into the 0-25 and 25-50-year increments. Given the high fixed costs of elevating a structure, the accrued benefits were insufficient to compensate for the high mobilization costs.

Table 2-11: Optimized Net NED benefits.

Optimized Net Benefit Analysis FY15 Price Level; 3.375% Discount Rate ($1,000s)			
Floodplain Increments	0–25-Year	25–50-Year	50–100-Year
First Cost	$824,025.22	$581,538.88	$915,876.78
Project Benefits	$265,963.65	$24,976.54	$17,239.18
Avg. Annual Cost	$34,342.49	$24,236.68	$38,171.09
Net Benefits	$231,621.16	$739.86	$(20,931.92)
B/C Ratio	7.74	1.03	0.45

In sum, the highest level of net benefits are associated with the **new NED TSP** known as **Modified Plan 8** which is based on the 0-25 Year Floodplain and which implements nonstructural measures to only those structures with FFEs between the 0-25-year flood stage in year 2025. While it is possible that an additional recommendation could be made to add in the 25-50-year increment since it does have positive net benefits, the recommendation for the Nonstructural 0-25 Year Floodplain Plan focuses the Federal investment on the most at-risk properties in the study area. It also indicates a clean break between increments due to the large disparity between the benefit/cost ratios. The **new TSP** (**Modified Plan 8**) as recommended in this Report replaces in its entirety, the previous TSP (Plan 7) as set forth in the December 2013 Initial Draft report. The current TSP is described in detail in Section 2.7 below and in Appendix L.

2.7 Description of the new NED Tentatively Selected Plan (Modified Plan 8).

1. Elevation of eligible residential structures. The term "Base Flood" is defined by the National Flood Insurance Program (NFIP) as the "flood having a 1% chance of being exceeded in any given year and is also called the 100 year flood." For the purposes of this Study this base flood elevation has been forecast into the future based on anticipated hydrologic conditions in the year 2075. This measure requires lifting the entire structure or the habitable area to the predicted 2075, 100-year base flood elevation unless the required elevation is greater than a maximum of 13 feet above ground level. The following process shall apply to property owners who are willing and eligible to participate in the elevation Program:
    - Property owner shall complete an application for structure elevation which must be signed by all owners and lien-holders of the property and structure);
    - Property must meet all eligibility criteria;
    - Property owner shall submit proof of ownership and a current Elevation Certificate;
    - The property has clear title and title research is completed;
    - Site inspection is conducted:
        - Phase I HTRW/Asbestos investigation is completed. The property must be certified as "clean" by the appropriate State office before any Project funds may be expended. All asbestos must be abated and disposed of properly;
        - A determination of suitability for elevation is made.
    - Elevation Agreement and Residential Structure Elevation Covenant Running With The Land are executed and recorded in the public records of the Parish in which the property is located.
    - Elevation of the structure is completed.

2. Dry flood proofing of eligible non-residential structures (excluding large warehouses and industrial complexes)*. Dry flood proofing consists of sealing all areas below the flood protection level of a structure to make it watertight and ensure that floodwaters cannot get inside by making walls, doors, windows and other opening impermeable to water penetration. Walls are coated with sealants, waterproofing compounds, or plastic sheeting is placed around the walls and covered, and back-flow from water and sewer lines prevention mechanisms such as drain plugs, standpipes, grinder pumps and back-up valves are installed. Common flood proofing measures include:

- Backflow valves;
- Closures on doors, windows, stairwells and vents--they may be temporary or permanent;
- Elevating structures via landfill, walls, posts, piers, jacks and beams;
- Rearranging or protecting damageable property--e.g., relocate or raise utilities;
- Sump pumps and sub-drains;
- Water resistant material; metal windows, doors and jambs; waterproof adhesives; sealants and floor drains.

*The following process will apply to property owners willing to dry-flood proof their structures for flood risk reduction.

- Property owner shall complete an application for dry flood proofing which must be signed by all owners and lien-holders of the property and structure);
- Property owner shall submit proof of ownership and a current Elevation Certificate;
- Site inspection is conducted;
    - Phase I HTRW/Asbestos investigation must be performed concurrently with the verification of application. The property must be certified as "clean" by the appropriate State office before any Project funds may be expended. All asbestos must be abated and disposed of properly. Asbestos impacted by flood proofing is removed at Project cost, while HTRW impacted by flood proofing must be remediated by the property owner prior to the initiation of the flood proofing work;
    - A determination of suitability for dry flood proofing for flood risk reduction is made;
- Some form of easement or developmental control agreement shall be required to be executed by the property owner and recorded in the public records of the parish where the property is located to prohibit future alteration of the dry flood proofing measures.
- Each structure that is dry flood proofed must have an approved sanitary disposal system and be in compliance with local and state health codes.
- The structure will be dry flood proofed.

3. Construction of flood proofing barriers or berms less than 6 feet in height around non-residential structures, primarily industrial complexes and warehouses*. These measures are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance requirements. Barrier or berms can be constructed of earth, concrete, masonry or steel and placed around a single structure or a contiguous group of structures.

*The following process will apply to property owners willing to have barriers less than 6 feet in height constructed around the structure(s) for flood risk reduction.

- Property owner shall complete an application which must be signed by all owners and lien-holders of the property and structure);
- Property owner shall submit proof of ownership and a current Elevation Certificate;
- Site inspection is conducted;

- Phase I HTRW/Asbestos investigation must be performed concurrently with the verification of application. The property must be certified as "clean" by the appropriate State office before any Project funds may be expended. All asbestos must be abated and disposed of properly. Asbestos impacted by flood proofing is removed at Project cost, while HTRW impacted by flood proofing must be remediated by the property owner prior to the initiation of the flood proofing work;
- A determination of suitability for the construction of small barriers for flood risk reduction is made;

- Some form of easement or developmental control agreement shall be required to be executed by the property owner and recorded in the public records of the parish where the property is located to prohibit future alteration of the barriers/berms constructed to reduce the risk of flooding .
- Each structure that is dry flood proofed must have an approved sanitary disposal system and be in compliance with local and state health codes.
- A barrier or berm of a height not to exceed 6 feet will be constructed around the structure(s).

4. Floodplain Management Plans. The NFS for the SWC Project is required to prepare a Floodplain Management Plan in coordination with USACE to maintain the integrity of the USACE Project. The NFS should use best efforts to work with the governing bodies within the three parishes to ensure consistency with local development plans and regulations across the Study Area.

5. Adoption of more stringent local floodplain regulations. Floodplain regulation and floodplain management are based in the NFIP which requires minimum standards of floodplain management and floodplain regulation for participating communities. Although communities within the SWC study area cannot change the minimum NFIP standards, local governments can adopt local standards that achieve higher levels of flood risk reduction, such as:
   - Replace elevation requirements based on the 100-year to the 500-year;
   - Implement a zero rise floodway; and
   - Adopt cumulative damages as the trigger for substantial damage determination.

6. Adoption of more restrictive parish and municipal building codes, land use & zoning regulations. and other developmental controls. Local governments within the floodplain should be encouraged to adopt and implement and enforce stricter building and housing code requirements, and land use and zoning regulations and other developmental controls aimed at reducing flood risk and flood damage. Examples include, restrictions on where new development may occur, minimum elevations for habitable first floors, requiring suitable anchorage to prevent flotation of buildings during floods; establishing minimum protection elevations for the first floors of structures; requiring electrical outlets and mechanical equipment to be above regulatory flood levels or be appropriately flood-proofed; restricting the use of materials that deteriorate when wetted; requiring adequate structural designs that can withstand the effects of water pressure and flood velocities; requiring the repair of flood- damaged structures in a manner that will ensure the safety of occupants and prevent blight.

2.7.1 Details of Residential Structure Elevation Program.

Participation in the Residential Non-Structural Program is primarily voluntary in nature. However, for properties that meet certain criteria, eminent domain authority will be utilized as warranted for acquisition of the land and structure and demolition of the structure.

Involuntary Participation.

Structures that meet criteria established by the Program for involuntary participation must be elevated or acquired; below is the criteria that will be used to determine structure inclusion in the Involuntary Program:

1. The structure is designated a "Severe Repetitive Loss" property in accordance with FEMA criteria (i.e. at least 4 NFIP payouts including building and contents of over $5,000 each payout with a cumulative payout total of over $20,000 OR is a residential property for which at least 2 separate claims payments (building only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. For both of the above, at least 2 of the claims must have occurred within any 10-year period and must be greater than 10 days apart. Currently there are:
    a. 358 residential properties meet the severe repetitive loss criteria.
    b. 7 commercial properties meet the severe repetitive loss criteria.
    c. 1 warehouse meets the severe repetitive loss criteria.

2. The structure is located in a Regulatory Floodway as established by FEMA. A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. 28 properties currently meet the regulatory floodway location criteria.

3. The structure constitutes a danger to public safety in that the un-remediated condition of the structure poses a substantial and certain risk of harm, death, injury or property damage if the structure ("At-risk Structure") is subjected to the forces, conditions, and risks typically associated with hurricanes and tropical storms and storm surge flooding. A non-exhaustive list of conditions that may warrant the condemnation of an At-risk Structure include: structures located in high hazard and repetitive loss areas, floodways or floodplains that are at significant risk of collapse or actual failure if exposed to the impacts of hurricanes, tropical storms and associated storm surge, flooding, wave action, winds and erosion. At-risk structures may include structures that are in a dilapidated, unsafe, and uninhabitable condition including but not limited to, structures that have severely cracked, collapsed or unsound foundations; structures with visible damage to or cracking in load bearing and masonry walls; structures with corroded, distressed, or defective steel or wood framings; structures with significant water and/or insect damage; structures with significant roof damage; structures with other structural defects that render it unsuitable for elevation; structures that have substantial damage such that the cost of restoring the structure to its before-damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred.

Some or all of these criteria may be modified or eliminated and additional criteria may be added as the Implementation Plan is finalized. If a property owner owns a structure that is included in the Involuntary Program, the Non-Federal Sponsor will use its eminent domain authority to acquire the property and relocate the occupant. Landowners and tenants of structures that are identified as Involuntary Program participants may be eligible for certain benefits in accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970, Public Law 91-646, 84 Stat. 1894 (42 U.S.C. 4601), as amended by the Surface Transportation and Uniform Relocation Assistance Act of 1987, Title IV of Public Law 100-17, 101 Stat. 246-256**;** 49 Code of Federal Regulations 24; and HUD Handbook 1378.

Voluntary Participation.

Residential structures that are eligible for elevation (and willing property owners) must meet the following eligibility criteria:

1. The property owner is willing to participate in the nonstructural program;
2. The structure is in a decent, safe, and sanitary condition and is otherwise suitable for human habitation;
3. The property has clear title;

4. The structure can be elevated to meet the required Base Flood Elevation so that the habitable floors are raised to levels which will protect the residential structures from storm surge flooding to reduce future losses from the likelihood of the 100-Year Flood Event to the extent practicable. However, in no event will a structure be raised greater than 13 ft above the ground level;
5. The structure and/or land is not contaminated with hazardous, toxic, or radioactive waste or materials;
6. The property owner is willing to execute a Flood Proofing Agreement and a Residential Structure Elevation Covenant Running with the Land;
7. Based on a visual assessment, the structure does not have signs of significant structural defects, distress, or failure (i.e., no evidence of extensive corrosion of steel framing or concrete; no substantial water or insect damage to wood framing and no framing that is in obvious need of extensive repair or replacement; no major settlement, cracking, buckling, or collapse of the foundation; no critical damage to load bearing or masonry walls; no major unrepaired roof leaks, etc.);
8. The property owner does not owe taxes or other debts to any state or local governmental entity or to the Federal government;
9. The property is located in a community/parish that participates in the National Flood Insurance Program and the property owner has a current Elevation Certificate;
10. The property owner has not previously received any disaster assistance for the elevation of the structure;
11. The structure complies with the building code and floodplain management codes under which the structure was originally permitted;
12. The property owner is willing to expend costs that *may* be necessary in connection with the elevation of the structure which are not eligible costs that are covered by the program;
13. There are no special considerations or unique circumstances which prohibit elevation.

Note: Tenants who reside in structures being elevated may be eligible for certain benefits in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and federally Assisted Programs of 1970, Public Law 91-646, 84 Stat. 1894 (42 U.S.C. 4601), as amended by the Surface Transportation and Uniform Relocation Assistance Act of 1987, Title IV of Public Law 100-17, 101 Stat. 246-256**;** 49 Code of Federal Regulations 24; and HUD Handbook 1378.

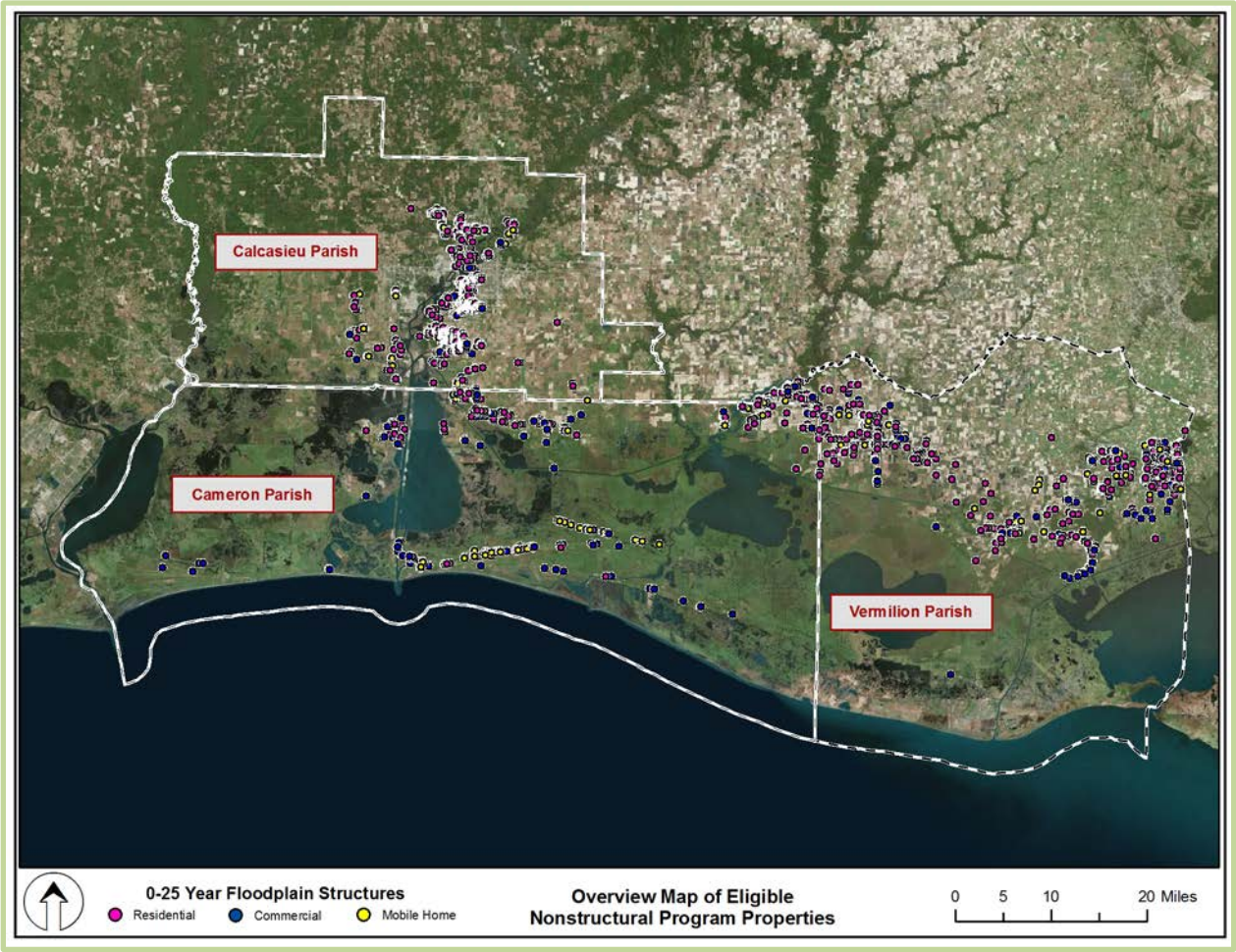

Figure 2-6: Eligible structures in the 0-25-year floodplain.

2.7 NER Alternative Plan Formulation

The Louisiana Chenier Plain extends from the western bank of Freshwater Bayou westward to the Louisiana-Texas border in Sabine lake, and from the marsh areas just north of the GIWW south to the Gulf of Mexico in Calcasieu, Cameron, and Vermilion parishes. Coastal erosion in the Chenier Plain accounts for approximately 20 percent of the land loss in Louisiana. The January 31, 2005 Chief's Report for the ecosystem restoration of the LCA suggested reducing wetlands losses by 50 percent as a possible desirable outcome from restoration efforts, including the development of a comprehensive restoration plan for the Chenier Plain ecosystem. The entire study area (see Figure 2-7) was considered for NER plan formulation. Although a significant portion of the area within the Coastal Zone Management Area has already received funding from other sources to address coastal land loss (Figure 2-7), this study does consider overlapping features in those areas.

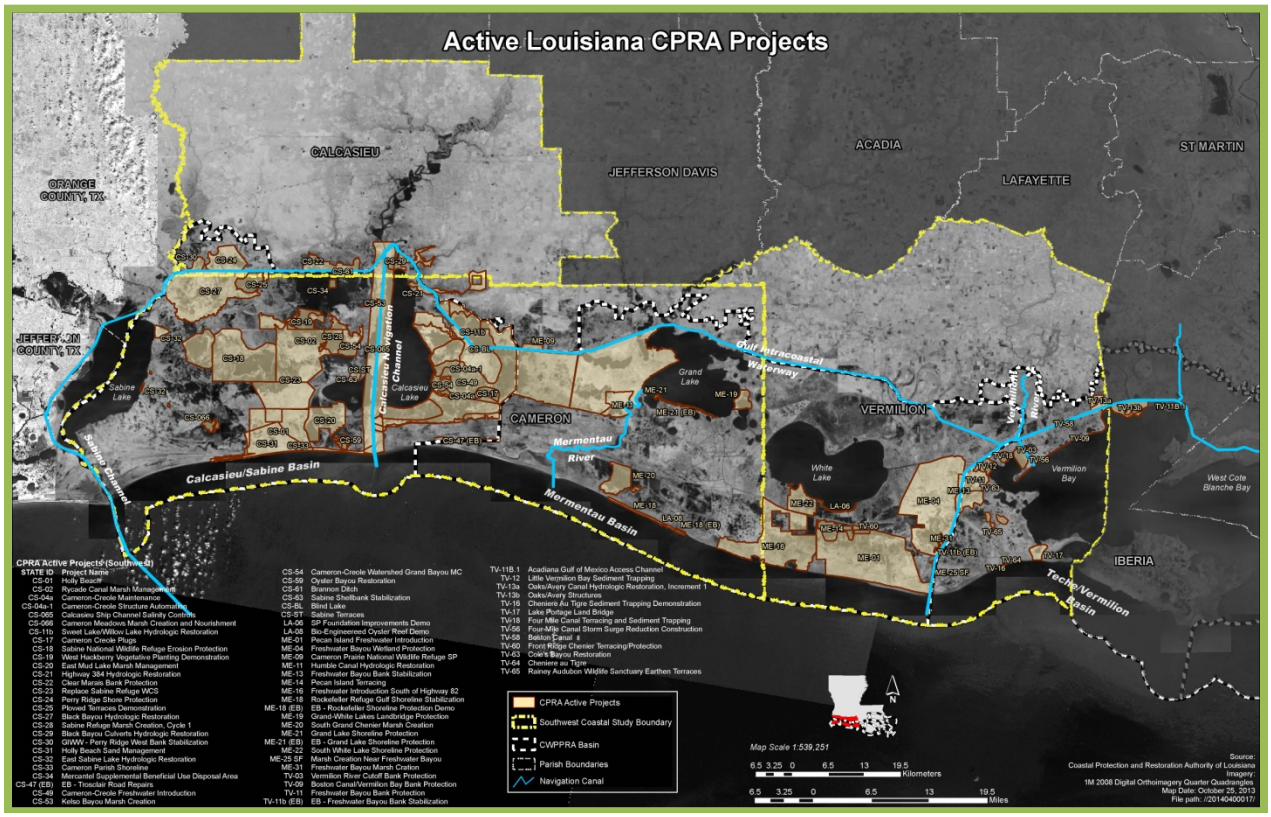

Figure 2-7: Restoration projects in the study area.

The principle areas of focus for the LCA plan formulation are the Calcasieu-Sabine Basin located between the GIWW and the Gulf of Mexico, primarily in the vicinity of Calcasieu and Sabine Lake and the Mermentau/Teche-Vermilion Basins between the GIWW and Gulf of Mexico, Vermilion Bay, and LA-27 to the west.

As part of the adaptive management and project planning process, a conceptual ecological model ("CEM") (Appendix A; Annex L) was developed to help explain the general functional relationships among the essential components of the Southwest Coastal Louisiana area. CEMs are a means of:

(1) Simplifying complex ecological relationships by organizing information and clearly depicting system components and interactions;
(2) Integrating to more comprehensively implicit ecosystem dynamics;
(3) Aids in identifying which species will show ecosystem response;
(4) Interpreting and tracking changes in restoration/management targets; and
(5) Communicating these findings in multiple formats.

This CEM assists with identifying those aspects where the project can effect change. Specifically, the CEM identifies those major stressors, ecosystem drivers, and critical thresholds of ecological processes and attributes of the natural system likely to respond to restoration features. The project CEM was used to assist in identifying problems and opportunities, refining project objectives and restoration management actions, selecting those attributes to be used as performance measures, modeling for alternative analysis, and monitoring for project success. The project CEM represents the current understanding of these factors and will be updated and modified, as necessary, as new information becomes available to assist with developing adaptive management and monitoring during project planning and implementation.

The CEM (Figure 2-8) was developed in conjunction with the USACE Engineering Research and Development Center (ERDC)and identified five drivers, seven ecological stressors, and four ecological effects. The most serious problem is the rate of land and habitat loss.

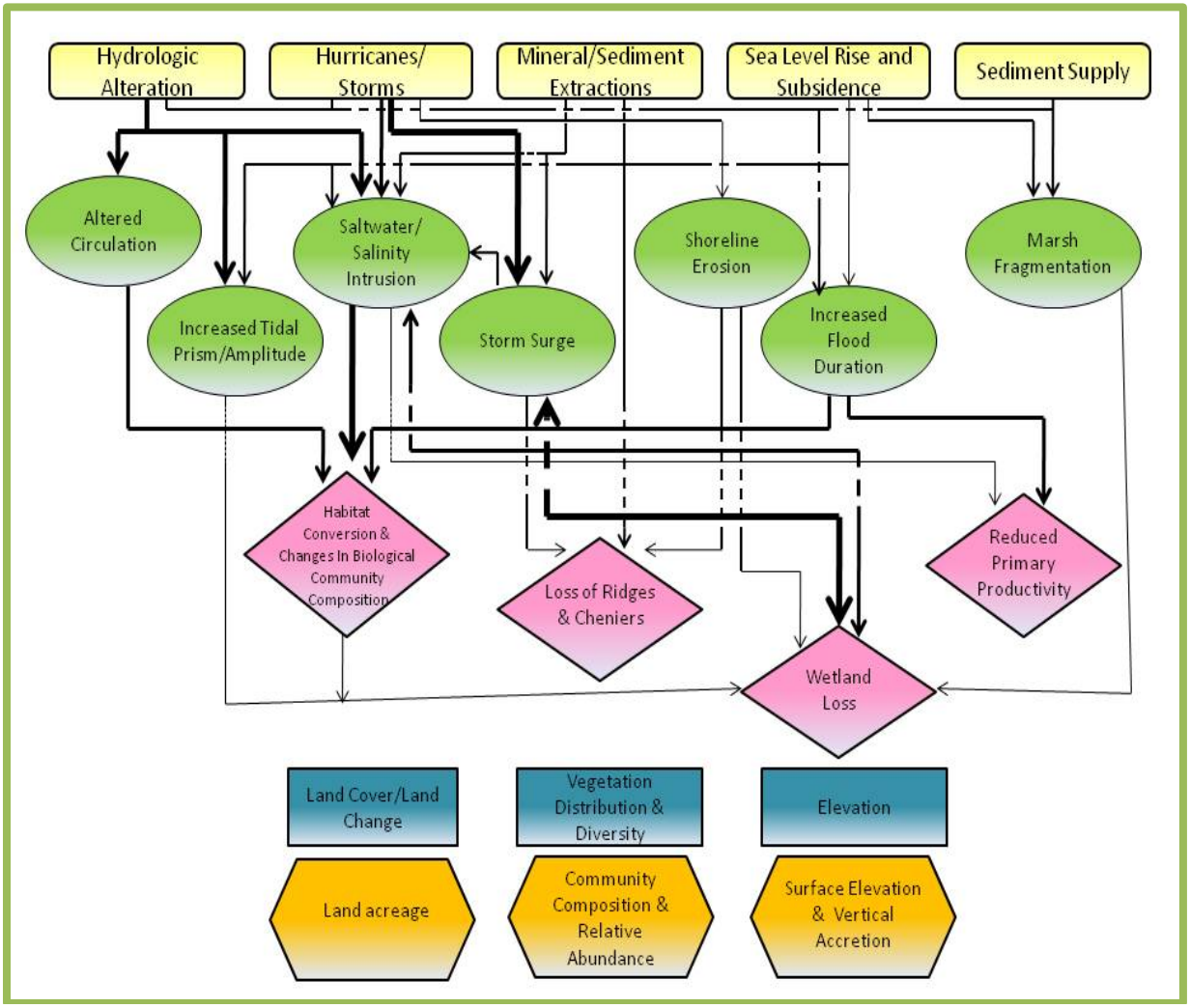

Figure 2-8: Conceptual ecological model.

2.7.1 NER Measures (*NEPA Required)

The PDT used a number of prior studies and reports to identify potential measures and screening criteria, including Federal projects authorized or constructed by the CWPPRA program; the USACE Continuing Authorities Program; the LCA Ecosystem Restoration Study (USACE 2004); and the LACPR Study (USACE 2009); 2012 State Master Plan, and the U.S. Department of Interior's CIAP.

The PDT recommended five measures to meet the NER goals and objectives:

1. **Marsh restoration.** Consists of marsh restoration and/or nourishment to increase land coverage in the area, and improve terrestrial wildlife habitat, hydrology, water quality, and fish nurseries. Vegetative plantings and herbivory control were deemed unnecessary for this feature.
2. **Bank and shoreline protection/stabilization.** Protection/stabilization features to reduce the rate of erosion at canal banks and shorelines in critical areas and to improve hydrology.
3. **Hydrologic and salinity control structures.** Control structures to manage water flow and minimize saltwater intrusion into marshes.

4. **Chenier reforestation.** Reforestation to restore native trees to the Chenier ecosystem, and reduce land loss rates and control for invasive plant and animal species.
5. **Oyster reef preservation** To restore and preserve these native features, and reduce shoreline erosion rates.

2.7.1.1 Initial Screening of NER Measures

Initial data collection included over 200 features which were mostly basin and/or location specific, but some applied to the overall study area. The first screening removed features that did not address project goals and objectives. The marsh restoration and shoreline protection/stabilization features were evaluated with the Wetland Value Assessment (WVA) model, and compared to costs to evaluate cost-effectiveness. Measures that were not cost-effective were eliminated unless the location served a critical geomorphologic function.

Measures were screened using the following criteria:

- **Constraints and Goals.** Measures that were not expected to be sustainable were eliminated such as marsh restoration measures located in currently open water areas where water depth is greater than 2 feet or in high subsidence areas along with chenier reforestation in locations with elevations less than 5 feet and areas with high shoreline erosion rates.
- **Objectives.** These criteria served as verification of previous screenings, to ensure that the measures being considered for inclusion were applicable to SWC objectives. Each of the measures was found to support the relevant objective. For example marsh restoration measures were eliminated if they did not support any critical landscape features.
- **Effectiveness.** Measures which were more effective in meeting the objectives were carried forward. In areas where marsh is deteriorating and shoreline protection, marsh restoration, or hydrologic and salinity control measures could potentially benefit the areas, the measure that would most benefit the area was retained, and the others were screened. Oyster reef preservation measures were all considered to be effective measures.. These thresholds were qualitatively developed by the PDT to establish a minimum criterion for success, to eliminate features that were not worth the Federal investment, and to avoid creating a grossly over-manipulated system.
- **Efficiency.** The final criteria compared cost per acre within the measure categories. If two measures produced the same benefits but one was less expensive to construct, the cheaper option was carried forward. For example, the West Cove marsh restoration measures were eliminated because the Mud Lake measure would provide restoration at a cheaper cost. Additionally, marsh restoration measures that benefitted more than 100 acres were more cost-effective (efficient) than those with a benefit of less than 100 acres, due to economies of scale with the costs of mobilization and demobilization.

The results of the NER screening evaluation are presented in Table 2-12.

Table 2-12: NER screening evaluation.

Screening Criteria		Application to Each NER Measure Category				
		Marsh Restoration	**Bank and Shoreline Protection/ Stabilization**	**Chenier Reforestation**	**Hydrologic & Salinity Control**	**Oyster Reef Preservation**
Constraints and Goals	Measure violates one of the study planning constraints or goals.	Features that are not sustainable do not meet the sustainability goal and were eliminated e.g. marsh areas where water depth is > 2 feet or local subsidence is high.	None of the shoreline stabilization features were eliminated.	Features that did not meet the sustainability goal were eliminated. Elevations < 5 ft NAVD 88 and areas exposed to high rates of shoreline erosion were screened.	None of the hydrologic or salinity control features were eliminated.	None of these features were eliminated.
Objectives	Measure does not address one or more of the study planning objectives.	All marsh restoration measures meet Objective 5. No marsh restoration features were eliminated.	All shoreline protection/stabilization measures meet Objective 4. No shoreline stabilization features were eliminated.	All Chenier reforestation measures meet Objective 5. No Chenier features were eliminated.	All hydrologic and salinity control measures meet Objective 2. No control features were eliminated.	All measures meet Objective 5. No oyster reef preservation features were eliminated.
Effectiveness	Measure found to be ineffective.	Marsh restoration features were more effective in areas with severe marsh degradation. Shoreline protection features were more effective in areas with existing marsh that was subjected to erosion from adjacent waterways.		Features were eliminated where existing canopy coverage deemed substantially intact (i.e., >50%) or if the presence of development would prohibit reforestation.	A small number of hydrologic and salinity control features were eliminated as ineffective because they did not exhibit large-scale hydrologic benefits to wetlands in the Chenier Plain.	None of the oyster reef preservation features were eliminated Reef restoration is an effective method of using natural barriers against storm surges and saltwater intrusion.
Efficiency	Measure found to have below average efficiency.	The average cost of all marsh and shoreline features based on the initial evaluation was approximately $125,000/net acre. Features were considered inefficient and eliminated if they had greater than average cost/net acre. Features that are considered critical components of the system were not eliminated Features that are located adjacent to significant resources, such as Cheniers and wildlife refuges were also not eliminated. Marsh restoration or shoreline protection/ stabilization measures producing or protecting less than 100 net acres were considered to be inefficient.		All Chenier reforestation features were found to be relatively cost efficient in comparison to each other.	All control features were found to be relatively cost efficient in comparison to each other.	All reef preservation features were found to be relatively cost efficient in comparison to each other.

After the initial screening there were too many potential combinations of features for the PDT to effectively assess and evaluate, therefore, the PDT developed an additional methodology through *plan development strategies* to further screen features and develop an initial array of alternatives.

2.7.2 Initial Array of NER Alternative Plans categorized by measure type (*NEPA Required)

Individual features were developed for each of the 5 NER measures and formed into 5 separate plans. Each was based on the measure type and the associated features for that particular measure. In keeping with the overall study purpose of addressing ecosystem degradation in the entire Chenier Plain, one integrated restoration plan was developed that integrated all of the measure types across all basins. Because the coastal zone is the area in greatest need of environmental restoration, the locations for the implementation of all of the five measures types being considered are located south of the GIWW.

- **Hydrologic and Salinity Control Plan.** This plan contains 49 hydrologic and salinity control features.
- **Marsh Restoration Plan.** This plan contains 52 marsh restoration and/or nourishment features.
- **Shoreline Protection/Stabilization Plan**. This plan contains 50 bank and shoreline protection features.
- **Chenier Reforestation Plan**. This plan contains 35 reforestation features (with invasive species control).
- **Oyster Reef Preservation Plan.** This plan contains 10 oyster reef preservation features.
- **Integrated Restoration Across Basins Plan**. This plan consists of features from all five measure categories. It contains a variety of basin-specific and study area-wide features.

2.7.2.1 Screening of the Initial Array of NER Alternative Plans

Another screening (outlined below and more fully explained in Figure C-1 and Tables C-9, C-10, and C-11 of Appendix C) was conducted and more features were removed from further consideration. Land loss analyses were conducted by the U.S. Geological Survey (USGS) to assess whether an area is experiencing high land loss and in critical need of ecosystem restoration.

The following additional screening criteria were applied to the remaining features:

- **Reinforcement of Critical Landscape Features**. Features on or adjacent to a landscape feature designated as critical.
- **Reinforcement of Critical Infrastructure**. Features that restore wetlands from open water and that protect the continuity and function of critical infrastructure.
- **Synergy with Other Projects**. Features that protect or contribute to the benefits of other projects.
- **Scarcity/Diversity**. Features that reduce the loss of freshwater marsh(considered imperiled by the Louisiana Natural Heritage Program).
- **Robustness/Sustainability**. Features that are attached to land that will persist through the period of analysis.
- **Implementability Issues**. Features with no serious impediment precluding its timely implementation.

Features were subjected to more detailed analysis and WVAs were conducted using all available data (such as State Master Plan analyses) and assumptions based on professional experience and knowledge. The results of the WVAs were combined with cost estimates to select cost-effective features. The following plan features were screened (with more information available in Appendix C):

- **Marsh Restoration.** Marshes that reinforce critical geomorphic land forms (i.e., lake rims, navigation banklines, gulf shoreline), which would protect interior reaches, were given greater priority than interior marshes.
- **Bank and Shoreline Protection/Stabilization.** A single shoreline protection/stabilization feature consisting of: a foreshore rock dike along the toe of the Cameron-Creole levee, was eliminated due to lack of marsh between the proposed rock dike and the levee. Stabilization at this location did not supply many NER benefits and therefore the feature was removed from further consideration.
- **Hydrologic and Salinity Control.** A WVA analysis was not completed because the model cannot adequately describe the benefits of these features across such a large area. In general, the features that were carried forward were those that had larger-scale benefits, such as those that helped maintain greater than 500 net acres as determined by the State Master Plan models.
- **Chenier Reforestation.** Although strategic project areas to reforest cheniers were identified and evaluated, due to the relative affordability of this measure type no specific features were screened. It was

decided that all chenier reforestation features would move forward as part of a consolidated chenier reforestation program.

- **Sabine Lake Oyster Reef Preservation.** Several oyster reef projects were removed from further consideration due to very modest benefits and existing or planned funding through other programs. The PDT determined that the Sabine Lake Oyster Reef, should be preserved because its 3-dimensional structure provides valuable habitat for various fisheries species and it also provides some hydrologic benefits to the remainder of Sabine Lake. The feature carried forward consists of protecting, and preserving the Sabine Lake Oyster Reef by prohibiting the harvesting of oysters from the reef.

NER Alternative Plan Evaluation. The NER features that were eliminated in the secondary screening reduced the overall size of the initial array of alternative plans. The comprehensive effects of these alternatives (including the "No Action" alternative) were estimated using the State Master Plan models (i.e., Wetland Morphology, Eco-Hydrology, Vegetation, and various land loss analysis and hydrodynamic models). The outputs of these models supply the data for subsequent analysis using the WVA model. Hydrodynamic modeling using the MIKE FLOOD model was used concurrently to evaluate the restoration alternatives and help refine the features included in the alternatives (specifically the type, size, and operation of the hydrologic and salinity control features). Results from the additional models indicated that the NER objectives could not be met through the implementation of single-measure alternative plans and as a result, the single measure plans were eliminated. The Integrated Restoration Across Basins alternative was the only plan capable of meeting the study goals and objectives and was carried forward. Variations of the Integrated Restoration Across Basins alternative were developed in the formulation of the focused array to more thoroughly address study area problems.

2.7.3 Focused Array of NER Alternative Plans

Using seven restoration strategies (set forth below) developed from the findings from the initial array, plus the "No Action" alternative, a focused array of 27 alternative plans (Table 2-14) was developed containing different combinations of the features. The restoration strategies were applied both comprehensively across basins and individually to the Calcasieu-Sabine Basin and Mermentau/Teche-Vermilion Basin. Plans that were derived from the State Master Plan are identified with "SMP". The PDT also determined that a Calcasieu Ship Channel (CSC) Salinity Control Structure was worth evaluating as a stand-alone strategy/alternative.

The locations of the NER focused array of alternative plans are: (1) the Calcasieu-Sabine Basin between the GIWW and the Gulf of Mexico and primarily in the vicinity of Calcasieu Lake and (2) the Mermentau/Teche-Vermilion Basins which are primarily clustered south of Grand and White Lakes, and in the area surrounding Freshwater Bayou.

For analysis purposes, each alternative plan was divided into two geographic parts. Plans denoted with a "C" contain features located in the Calcasieu-Sabine Basin. Plans denoted with an "M" contain features located in the Mermentau and Teche-Vermilion Basins. The CSC Salinity Control Structure is the sole component of the seventh restoration strategy and a standalone alternative designated as Plan "A". CSC Salinity Control Structure (Plan "A") is also combinable with any plan containing a Calcasieu-Sabine Basin, or "C" component. Collectively, all of the features for each basin that comprise a restoration strategy are considered unique alternatives. Descriptions of each restoration strategy are presented below.

A listing of the specific features that are contained within each restoration strategy can be found in Table 2-13. Unique alternatives were generated based on restoration strategy and basin location.

NER Strategies

Strategy 0: **No Action Plan.**

Strategy 1: **Large Integrated Restoration (SMP).** The results of the State Master Plan Models were used to select only those hydrologic and salinity control features that showed the greatest benefits. For marsh restoration, features were selected that would best reinforce critical landscape features, with particular emphasis on areas that are exposed to saltwater, tidal, and wave action. Bank and shoreline protection/stabilization features were retained that protected the areas of greatest erosion. Strategy 1 is composed of 6 hydrologic and salinity control features, 19 marsh restoration features, 7 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 2: **Moderate Integrated Restoration (Hydrologic Emphasis) (SMP).** This restoration strategy has less investment in marsh restoration and bank and shoreline protection/stabilization features, but retains the same level of hydrologic and salinity control features as Strategy 1 due to the philosophy that hydrologic restoration is of great importance to the Chenier Plain. Marsh restoration features were focused on areas of critical importance for restoration. Bank and shoreline protection/stabilization features that protected the areas of greatest erosion were retained. Strategy 2 is composed of 6 hydrologic and salinity control features, 13 marsh restoration features, 4 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 3: **Moderate Integrated Restoration, Including Gum Cove (SMP).** This Strategy is identical to Strategy 2 except it includes the Gum Cove Lock feature. Strategy 3 was formulated to investigate the hydrologic restoration benefits and cost-effectiveness of the Gum Cove Lock combined with the Calcasieu Ship Channel Salinity Control Structure. Strategy 3 is composed of 6 hydrologic and salinity control features, 13 marsh restoration features, 4 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 4: **Small Integrated Restoration (SMP).** The focus of Strategy 4 is to use a minimal range of features focused at stabilizing perimeter geomorphology. This Strategy includes marsh restoration and bank and shoreline protection/stabilization features that could reinforce perimeters. Strategy 4 is composed of 2 hydrologic and salinity control features, 9 marsh restoration features, 2 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 5: **Interior Perimeter Salinity Control.** The focus of Strategy 5 is the control of salinity levels within the interior areas of the Calcasieu-Sabine basin and the Cameron-Creole Watershed. There are no hydrologic and salinity control structures at the main passes, with the expectation that salinity control around the perimeter of Calcasieu Lake and the GIWW could result in lower salinities in the interior marshes at a lower cost than entry salinity control. Strategy 5 includes those marsh restoration and bank and shoreline protection/stabilization features that could reinforce perimeters. Strategy 5 is composed of 6 hydrologic and salinity control features, 9 marsh restoration features, 2 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 6: **Marsh and Shoreline (Minimal Hydrologic & Salinity Control).** Strategy 6 includes minimal hydrologic and salinity control features and focuses on restoring marsh and protecting/stabilizing shorelines. Strategy 6 was formulated to evaluate the effectiveness of ecosystem restoration with the existing salinity regime and is composed of 5 hydrologic and salinity control features, 18 marsh restoration features, 5 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 7: **Entry Salinity Control (Stand-alone measure).** Strategy 7 would manage salinity introduced through the CSC into Calcasieu Lake and surrounding wetlands through a CSC Salinity Control Structure (Plan "A"). It is combinable with Calcasieu alternatives and is also evaluated as a stand-alone plan.

Table 2-13: Features within each Restoration Strategy

Feature Location: Mermentau Basin / Calcasieu Basin		No Action	Strategy 1/1A	Strategy 2/2A	Strategy 3/3A	Strategy 4/4A	Strategy 5	Strategy 6	Strategy 7 (or A)
Measure	Feature		Large Integrated Restoration across Basins	Moderate Integrated Restoration across Basins	Moderate Integrated Restoration + Gum Cove	Small Integrated Restoration	Interior Perimeter Salinity Control	Marsh & Shoreline Focus	Entry Salinity Control
Hydrologic & Salinity Control									
	7#	0	0/X	0/X	0/X	0/X	0	0	X
	13*	0	0	0	0	0	0	0	0
	17a-c*	0	0	0	0	0	0	0	0
	48	0	0	0	0	0	0	0	0
	74a	0	X	X	X	X	X	X	0
	407	0	0	0	X	0	X	0	0
Marsh Restoration									
	3a1	0	0	0	0	X	X	0	0
	3c1	0	X	X	X	X	X	X	0
	3c2	0	X	X	X	0	0	X	0
	3c3	0	X	X	X	0	0	X	0
	3c4	0	X	X	X	0	0	X	0
	3c5	0	X	X	X	0	0	X	0
	47a1	0	X	X	X	X	X	X	0
	47a2	0	X	X	X	X	X	X	0
	47c1	0	X	X	X	X	X	X	0
	47c2	0	X	0	0	0	0	X	0
	124a	0	X	0	0	0	0	X	0
	124b	0	X	0	0	0	0	X	0
	124c	0	X	X	X	X	X	X	0
	124d	0	X	X	X	X	X	X	0
	127c1	0	X	0	0	0	0	X	0
	127c2	0	X	X	X	0	0	X	0
	127c3	0	X	X	X	X	X	X	0
	306a1	0	X	X	X	X	X	X	0
	306a2	0	X	0	0	0	0	X	0
Shoreline Protection/Stabilization									
	5a	0	X	X	X	X	X	X	0
	6b1	0	X	X	X	X	X	X	0
	6b2	0	X	X	X	X	X	X	0
	6b3	0	X	X	X	X	X	X	0
	16b	0	X	0	0	X	X	0	0
	99a	0	X	0	0	0	0	X	0
	113b2	0	X	0	0	0	0	0	0
Chenier Reforestation (both basins)									
	CR	0	X	X	X	X	X	X	0

Feature 7 functions both as a stand-alone Strategy/Alternative and an additive feature. *Following refinement of the benefit assessment as a result of technical comments, these features were found to lack positive outputs and were dropped from all plans. Note: Green cells denote features found in the Calcasieu Basin. Blue cells denote features in the Mermentau Basin. An 'X' in a cell indicates the feature is a component of the strategy while a '0' indicates it is not a component of the strategy.

2.7.4 Comparison of the Focused Array of NER Alternative Plans

The calculated WVA benefits are measured in average annual habitat units (net AAHUs) and cost estimates were examined using the Institute for Water Resources Planning Suite (IWR Plan), the results of which helped guide the identification of a TSP. The State Master Plan Models were used to compare benefits among alternatives in acres and AAHUs, and compared them to the Future Without Project (FWOP) Alternative. The WVA analysis used to generate the benefits in AAHUs has six variables that must be projected into the future for the FWOP and Future With Project (FWP) alternatives.

The focused array of alternatives consists of alternative plans that align with a restoration strategy and contain the features the PDT identified as most supportive of achieving the goals of that restoration strategy. For the focused array of alternatives, the State Master Plan modeling effort was used with input from the Eco-hydrology module to estimate land and water changes. The alternatives were run under the Intermediate RSLR scenario to predict salinity, water levels, and flows. The results of this modeling effort were input into the Vegetation and Wetland Morphology modules of the State Master Plan modeling system to predict wetland loss and other trends over time. The State Master Plan model included accretion and subsidence projections. For marsh restoration and shoreline protection/stabilization projects, the WVA analysis process used inputs from these models, and was performed using basic assumptions from the CWPPRA program.

Table 2-14: NER Focused array of Alternative Plans

Alternative Plan/ Strategy#	IWR label	ALTERNATIVE PLAN NAME
A	A	Entry Salinity Control
C-1	C1	Calcasieu Large Integrated Restoration
M-1	M1	Mermentau Large Integrated Restoration
CA-1	C1A	Calcasieu Large Integrated Restoration w/ Entry Salinity Control
CM-1	C1+M1	Comprehensive Large Integrated Restoration
CMA-1	C1A+M1	Comprehensive Large Integrated Restoration w/ Entry Salinity Control
C-2	C2	Calcasieu Moderate Integrated Restoration
M-2	M2	Mermentau Moderate Integrated Restoration
CA-2	C2A	Calcasieu Moderate Integrated Restoration w/ Entry Salinity Control
CM-2	C2+M2	Comprehensive Moderate Integrated Restoration
CMA-2	C2A+M2	Comprehensive Moderate Integrated Restoration w/ Entry Salinity Control
C-3	C3	Calcasieu Moderate Integrated Restoration
M-3	M3	Mermentau Moderate Integrated Restoration
CA-3	C3A	Calcasieu Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
CM-3	C3+M3	Comprehensive Moderate Integrated Restoration
CMA-3	C3A+M3	Comprehensive Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
C-4	C4	Calcasieu Small Integrated Restoration
M-4	M4	Mermentau Small Integrated Restoration
CA-4	C4A	Calcasieu Small Integrated Restoration w/ Entry Salinity Control
CM-4	C4+M4	Comprehensive Small Integrated Restoration
CMA-4	C4A+M4	Comprehensive Small Integrated Restoration w/ Entry Salinity Control
C-5	C5	Calcasieu Interior Perimeter Salinity Control
M-5	M5	Mermentau Interior Perimeter Salinity Control
CM-5	C5+M5	Comprehensive Interior Perimeter Salinity Control
C-6	C6	Calcasieu Marsh & Shoreline
M-6	M6	Mermentau Marsh & Shoreline
CM-6	C6+M6	Comprehensive Marsh & Shoreline

Alternative plans are delineated by Strategy, geographic location (C=Calcasieu, M= Mermentau), and the potential inclusion of the CSC Salinity Control Structure (Plan "A").

2.7.4.1 Cost Estimates

The construction cost and schedule estimates were developed from similar projects in the Southwest Coastal Louisiana study area (such as through the CWPPRA program), with input as needed from other recent projects coast-wide. This includes mobilization and demobilization costs, price per cubic yard of dredged material or per ton of rock, depending on the measure type, and other line items as appropriate. The maintenance schedule for shoreline protection/stabilization was based on anticipated settlement rates calculated from the existing nearby geotechnical data, as available, and similar projects in the vicinity. The renourishment schedule for the marsh restoration features was developed through an optimization process by which the total costs and benefits for different maintenance schedules were considered at five-year intervals. This process determined that a 30-year renourishment cycle optimized costs per unit benefit (in average annual acres AAA). Costs for hydrologic and salinity control features were calculated, along with the features from the State Master Plan. The costs of alternative plans are the sums of the costs of the individual features (see Table 2-15). While some cost-savings may be realized through synergistic execution of adjacent or nearby project features, for a conservative cost estimate this synergy was not assumed. Since the NER plan is intended to reasonably maximize environmental benefits, and since NER planning promotes the avoidance of environmental features that require mitigation, any features that would require mitigation were screened from further consideration and no costs for unavoidable wetland impacts have been factored into the preliminary cost estimates. All restoration features in the various alternatives have been designed to not require mitigation. Preliminary high and low cost estimates for plans that contain Plan "A" (CSC Salinity Control Structure) were developed as starting points to account for potential navigation impacts.

Table 2-15: NER Cost Estimates and Benefits

Plan #	Cost $ Low Nav	Cost $ High Nav	AAA's
CMA-1	3,049,836,909	3,104,429,860	29,070
CM-1	2,465,675,681	2,465,675,681	23,101
CA-1	1,591,668,028	1,646,260,979	12,844
C-1	1,007,506,800	1,007,506,800	6,875
M-1	1,458,168,881	1,458,168,881	16,226
CMA-2	2,390,030,484	2,444,623,435	25,187
CM-2	1,901,658,190	1,901,658,190	19,218
CA-2	1,495,879,094	1,550,472,045	13,898
C-2	1,007,506,800	1,007,506,800	7,929
M-2	894,151,390	894,151,390	11,289
CMA-3	2,697,850,484	2,752,443,435	18,959
CM-3	2,113,689,256	2,113,689,256	12,990
CA-3	1,803,699,094	1,858,292,045	7,982
C-3	1,219,537,866	1,219,537,866	2,013
M-3	894,151,390	894,151,390	10,977
CMA-4	1,903,984,167	1,958,577,118	22,508
CM-4	1,319,822,939	1,319,822,939	16,539
CA-4	1,041,573,707	1,096,166,658	11,005
C-4	457,412,479	457,412,479	5,036
M-4	862,410,460	862,410,460	11,503
CM-5	1,664,058,939	1,664,058,939	15,537
C-5	801,648,479	801,648,479	4,457
M-5	862,410,460	862,410,460	11,080
CM-6	2,321,547,245	2,321,547,245	23,026
C-6	1,005,766,800	1,005,766,800	9,240
M-6	1,315,780,445	1,315,780,445	13,786
A	584,161,228	638,754,179	5,969

- Price level for feature costs – June 2013 and Discount rate of 3.5% (FY 2014) for navigation delays

2.7.4.2 CE/ICA Results

The focused array of alternative NER plans were compared considering cost effectiveness and incremental cost analysis (CE/ICA) to inform environmental investment decision making. Cost effectiveness is determined based upon a finding that no other plan provides a higher output level of acres restored for the same or less cost. Incremental cost analysis is the determination of the greatest increase in output (acres restored) for the least increase in cost. Use of these tools helps decision makers determine the most desirable level of outputs (restored acres) compared to costs.

In the CE/ICA analysis shown in Figure 2-9, a Rough Order of Magnitude (ROM) average annual cost of $10,000,000 was added to plans that include CSC Salinity Control Structure (Plan "A") to represent the potentially high navigation impact cost resulting from the operable closure structure. The cost in this analysis represents traffic delays to all 2011 deep draft traffic in the CSC. All alternatives with Plan "A" were run through CE/ICA both with and without the structure in place in order to isolate the relative performance of the structure. Plans in red are best-buys and those in blue are cost-effective.

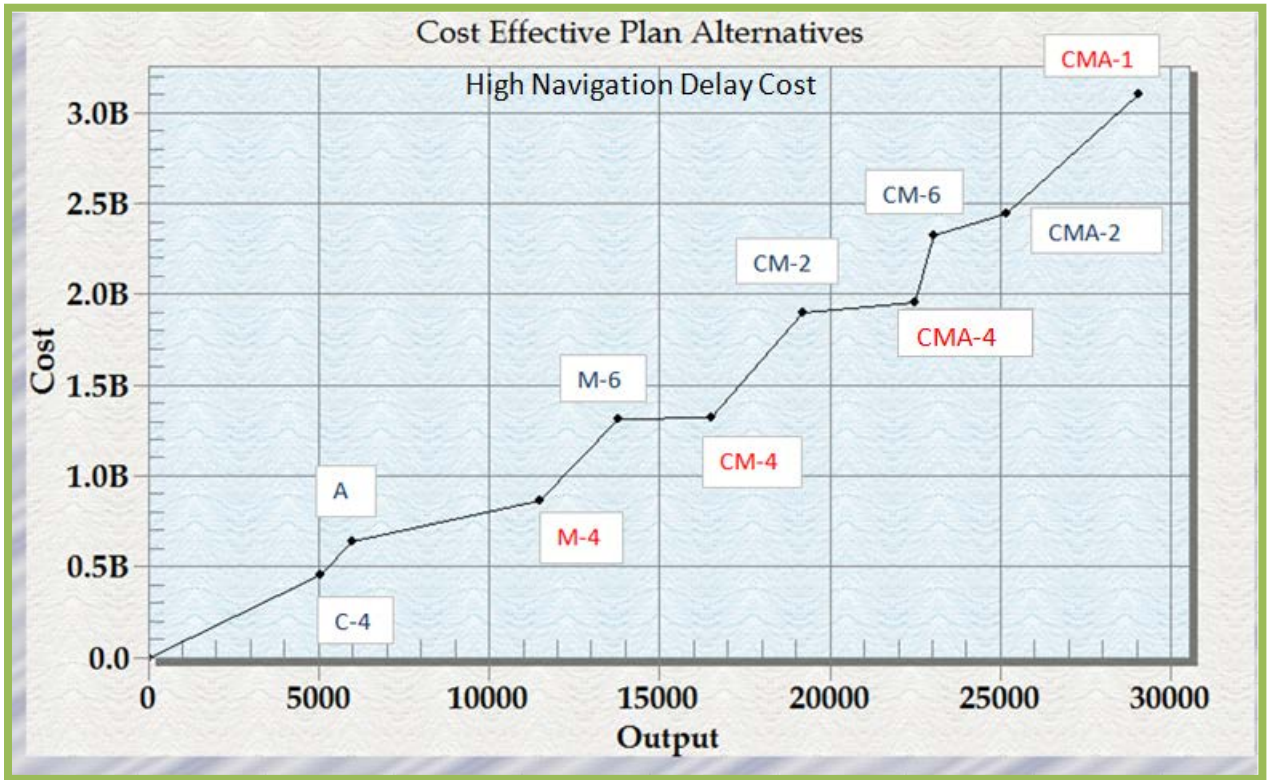

Figure 2-9: CE/ICA analysis using high navigation cost.

The second CE/ICA analysis is shown in Figure 2-10. Identical sets of plans were run, but they used a lower ROM average annual cost of $7,672,500 to represent navigation delay costs caused by the CSC Salinity Control Structure. The lower cost accounts for delays to vessels that transited on the CSC in 2011 with drafts between 15 and 35 feet. The purpose of using this lower cost estimate is to represent an operating scheme that would allow the CSC Salinity Control Structure to remain open during high tide, which is when the deepest draft vessels transit. Thus, a minimum representation of the impact of the structure closure is to add traffic delays for only non-deep-draft vessels. The cost does not include tug assistance costs or any other ancillary impacts of a closure of the CSC Salinity Control Structure. In both analyses, in order to be consistent with the cost provided for the measures, the average annual cost was converted to a present value of

$179,963,228. This present value cost was added to the cost of the plans that contain the CSC Salinity Control Structure, which includes any Plan with an "A" designation.

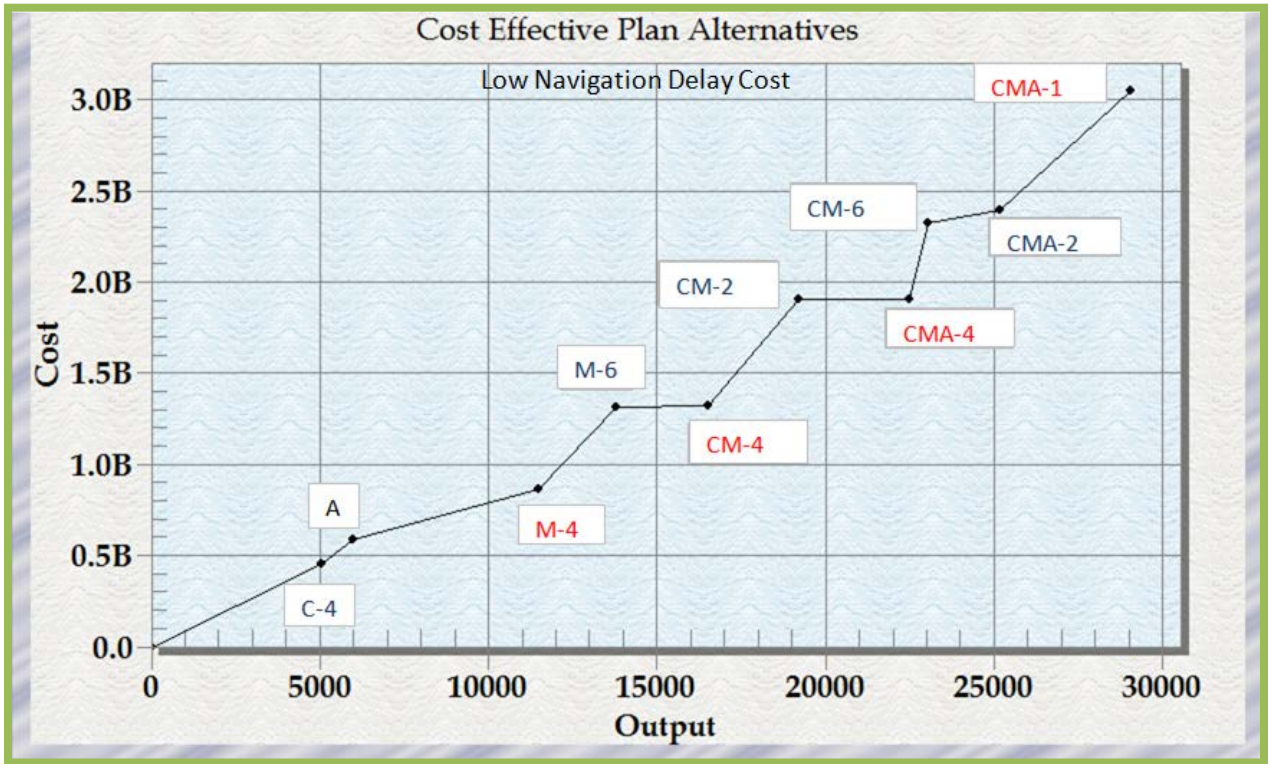

Figure 2-10: CE/ICA analysis using low navigation cost.

For all focused array alternatives, the number of hydrologic and salinity control structures, marsh restoration features, and bank and shoreline protection/stabilization features varied depending on the plan scale and restoration strategy. The plans were estimated to produce between 5,000 and 29,000 AAAs, and their costs range from $500,000,000 to over $3,000,000,000.

The CSC Salinity Control Structure (Plan "A") Considerations

As part of the evaluation, plans with and without the CSC Salinity Control Structure were compared. The salinity control structure could potentially provide significant environmental benefits (5,700 AAAs) even as a stand-alone plan (Plan "A"). The applications of both low and high preliminary rough order of magnitude estimates of navigation impacts indicated the salinity control structure to be potentially cost-effective. However, Best-Buy plans that contain the CSC salinity control structure, (which includes any Plan with an "A" designation), are significantly more expensive than plans without the CSC structure. Other cost-effective and Best-Buy comprehensive plans containing the CSC structureexist only on the upper most portion of the cost efficient frontier.

When the CSC structure is evaluated as a stand-alone plan, it is anticipated that a more detailed level of analysis would reveal higher navigation impact costs. As a result, the CSC structure as a stand-alone alternative, does not indicate that it could be a Best-Buy plan or be selected as the TSP and may in fact fall completely out of consideration should costs be found to be higher than what was estimated by the PDT and fed into the IWR planning suite.

However, if additional benefits beyond the current TSP are desired, alternatives that include the CSC structure are worth considering. In the long-term there is a good chance that the addition of the CSC

structure could provide the next best increment of benefit, even if costs are found to be higher. In the end, the only Best Buy plans that produce greater benefits than the identified TSP are those which include the CSC salinity cntrol structure as a component.

2.7.5 Final Array of NER Alternative Plans (*NEPA Required)

The final array is comprised of the No Action Plan, Plan M-4, and Plan CM-4. The IWR analysis indicates that the only Best Buy plans that do not contain the CSC salinity control structure are plans M-4 and CM-4. Since the negative effects of the CSC structure to navigation are a study constraint and due to the significant cost of the CSC structure, those Best Buy plans on the upper portion of the cost-efficient frontier were dropped from the final array. The components of the final array plans are presented in the table below. Plan M-4 features are those that are located in the Mermentau/Teche-Vermilion basin. Plan CM-4 consists of all the features listed in Table 2-16.

Table 2-16: Features of the NER Final Array Alternative Plans

Basin (Final Array Plan Name)	Category	Feature	Description
Mermentau/Teche-Vermilion (Plan M-4)	Hydrologic/ Salinity Control	13	Little Pecan Bayou Saltwater Sill. Construction of a rock weir with a crest (top) elevation of -3.1 ft and an opening of 60 ft at a bottom invert of -11.1 ft.
	Marsh Restoration	47a1	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 933 marsh acres would be restored and 88 acres would be nourished from 3M cubic yards of dredged material with one future renourishment cycle.
		47a2	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 1,297 marsh acres would be restored and 126 acres would be nourished from 8.8M cubic yards of dredged material with one future renourishment cycle.
		47c1	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 1,304 marsh acres would be restored and 4 acres would be nourished from 8.6M cubic yards of dredged material with one future renourishment cycle.
		127c3	Marsh restoration at Pecan Island west of the Freshwater Bayou Canal and about 5 miles north of the Freshwater Bayou locks. 832 marsh acres would be restored and 62 acres would be nourished from 7.3M cubic yards of dredged material with one future renourishment cycle.
		306a1	Rainey marsh restoration at Christian Marsh east of the Freshwater Bayou Canal and about 5 miles north of the Freshwater Bayou locks. 627 marsh acres would be restored and 1,269 acres would be nourished from 8.1M cubic yards of dredged material with one future renourishment cycle.
	Shoreline Protection/ Stabilization	6b1	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 11.1 miles of shore protection consisting of a reef breakwater with a lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 2,140 acres of existing marsh.
		6b2	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 8.1 miles of shore protection consisting of a reef breakwater with a lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 1,583 acres of existing marsh.
		6b3	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 7.2 miles of shore protection consisting of a reef breakwater with a

			lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 1,098 acres of existing marsh.
		16b	Fortify Freshwater Bayou. bank with 15.4 miles of rock revetment at three critical spots to prevent breaching. Revetment would be built to +4 ft with a 4 ft crown. Two maintenance lifts will be required. The breakwater would protect 662 acres of existing marsh.
	Chenier Reforestation	CR	Replant 13 chenier locations. Approximately 435 seedlings per acre, at 10 ft x 10 ft spacing, with invasive species control incorporated.
Calcasieu/ Sabine (Plan CM-4) (Includes all features in Plan M-4)	Hydrologic/ Salinity Control	74a	Cameron-Creole Spillway. Located at the breach in the levee south of Lambert Bayou. The canal would act as a drainage manifold. The outfall channel into Calcasieu Lake would be rock-lined for scour protection and built to +4 ft.
	Marsh Restoration	3a1	Beneficial use of dredged material from the Calcasieu Ship Channel. Adjacent to the south shore of the GIWW west of the ship channel near Black Lake. 599 marsh acres would be restored from 5.3M cubic yards of dredged material with one future renourishment cycle.
		3c1	Beneficial use of dredged material from the Calcasieu Ship Channel. Adjacent to the east rim of Calcasieu Lake within the Cameron-Creole Watershed. 1,765 marsh acres would be restored and 450 acres would be nourished from 10.2M cubic yards of dredged material with one future renourishment cycle.
		124c	Marsh restoration at Mud Lake. Located adjacent and north of Highway 82 and east of Mud Lake. 1,908 marsh acres would be restored and 734 acres would be nourished from 11.1M cubic yards of dredged material with one future renourishment cycle.
		124d	Beneficial use of dredged material from the Calcasieu Ship Channel for marsh restoration at Mud Lake. Located west of the Calcasieu Ship Channel and adjacent to the southern rim of West Cove. 159 marsh acres would be restored and 448 acres would be nourished from 1.4M cubic yards of dredged material with one future renourishment cycle.
	Shoreline Protection/ Stabilization	5a	Holly Beach Shoreline Stabilization Breakwaters. Construction of approximately 8.7 miles of rock and low action breakwaters and is a continuation of existing breakwaters. Crown elevation of +1.5 ft with a crown width of 30 ft. Two maintenance lifts will be required. The breakwater would protect 158 acres of inter-tidal habitat.
	Chenier Reforestation	CR	Replant 22 chenier locations. Approximately 435 seedlings per acre, at 10 ft x 10 ft spacing, with invasive species control incorporated.
	Oyster Reef Preservation	ORP	Preservation of a large oyster reef in Sabine Lake through the enforcement of oyster dredging restrictions.

Plan 0: **No Action.** As detailed in Chapter 1, under this alternative, no ecosystem restoration would take place. Coastal wetlands would continue to degrade and disappear, further weakening the coastal landscape resulting in significant impacts to important habitats. Infrastructure, populations, industry, and businesses would continue to become vulnerable to the increased effects of storm surge and RSLR through the loss of a protective wetland buffer.

Plan M4: **Mermentau Small Integrated Restoration.** This alternative was formulated for NER so it does not have specific NED or RED benefits calculated. Effects to EQ would increase for this alternative but only for the Mermentau Basin. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and improvement to the coastal landscape.

Plan CM-4: **Comprehensive Small Integrated Restoration (Tentatively Selected Plan).** This alternative was formulated for NER. It does not have specific NED or RED benefits calculated. Effects to EQ would increase for the alternative across the Calcasieu and Mermentau Basins. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and

improvement to the coastal landscape. This alternative offers the most cost-effective and comprehensive benefit.

2.8 Summary of Accounts and Comparison of Alternatives

To facilitate alternatives evaluation and comparison, the 1983 Principles and Guidelines set up four Federal Accounts to assess the effects of alternatives. The accounts are National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

- The NED account displays changes in the economic value of the national output of goods and services. The 1983 Principles and Guidelines require identification of an NED plan from among the alternatives.
- The EQ account displays non-monetary effects on significant natural and cultural resources.
- The RED account registers changes in the distribution of economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
- The OSE account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

NER TSP

The Corps objective in ecosystem restoration planning is to contribute to NER. Contributions to NER (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. The TSP must be shown to be preferable to taking no action (if no action is not recommended) or implementing any of the other alternatives considered during the planning process. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The TSP must be shown to be cost-effective and justified to achieve the desired level of output.

Plan 0: **No Action.** As detailed in Chapter 1, under this alternative, no ecosystem restoration would take place. Coastal wetlands would continue to degrade and disappear, further weakening the coastal landscape resulting in significant impacts to important habitats. Infrastructure, populations, industry, and businesses would continue to become vulnerable to the increased effects of storm surge and relative sea-level rise (RSLR) through the loss of a protective wetland buffer.

Plan M4: **Mermentau Small Integrated Restoration.** This alternative was formulated for NER so specific NED or RED benefits were not calculated. Effects to EQ are increased but only for the Mermentau Basin. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and improvement to the coastal landscape.

Plan CM-4: **Comprehensive Small Integrated Restoration (TSP).** This alternative was formulated for NER so specific NED or RED benefits were not calculated. Effects to EQ increase only in the Calcasieu and Mermentau Basins. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and improvement to the coastal landscape. This alternative provides the most cost-effective and comprehensive benefit.

2.8.1 Additional Evaluation in Response to Comments

Technical comments received during public and agency review of the initial draft report resulted in several changes to the original TSP. Technical reviewers recommended removal of the Sabine Lake Oyster Reef Preservation feature since there is no cost for its implementation, it lacks quantifiable benefits, and it can be handled administratively by the agency in charge of its management. Comments also resulted in the formal recommendation that the CSC structure be addressed in a long-term study because there are too many uncertainties about its potential effect on salinity and its potential impacts to navigation. It also needs complex and detailed hydrodynamic and navigation economics modeling that the SWC study effort is not scoped to support at this time.

The inputs to the IWR Planning Suite were refined utilizing annualized costs as well as annualized habitat units from an updated and certified version of the WVA model. These values were developed and additional analysis of the NER focused array of alternatives was completed based on the refinements in benefits and costs for all features in each alternative. This effort helped identify features that fell short of initial benefits projections. For example, the Little Pecan Bayou Saltwater Sill (Feature 13) had significantly fewer benefits than originally projected based on the refined analysis and was therefore removed as a component from all alternatives. The focused array of alternatives was re-run in IWR without Feature 13 and based on the adjustments to annualized benefits and costs. The outputs from these adjustments are presented below (see Table 2-17 and Figure 2-11).

Table 2-17: NER cost efficient alternative plan comparison.

Plan Name	Total Cost x 1,000	Annual Cost	AAHUs	Cost/AAHU	Cost Effective Status
CMA-1	$2,742,583	$117,534,339	10,543	$260,133	Best Buy
CM-1	$2,137,807	$91,750,472	9,548	$223,901	Best Buy
CM-6	$2,009,393	$86,265,228	9,333	$215,299	Best Buy
CM-3	$1,855,589	$79,110,630	8,218	$225,795	Yes
CM-2	$1,571,945	$67,017,839	8,038	$195,564	Best Buy
CM-5	$1,447,594	$61,716,322	6,080	$238,091	Yes
CM-4	$1,197,757	$49,623,531	5,901	$202,975	Yes
C-1	$821,105	$34,998,133	4,682	$175,374	Best Buy
C-2	$736,060	$31,372,342	4,242	$173,517	Best Buy
C-5	$666,997	$28,427,927	2,533	$263,322	Yes
C-4	$383,353	$16,335,136	2,353	$162,920	Best Buy
No Action Plan	$0	$0	0	$0	Best Buy

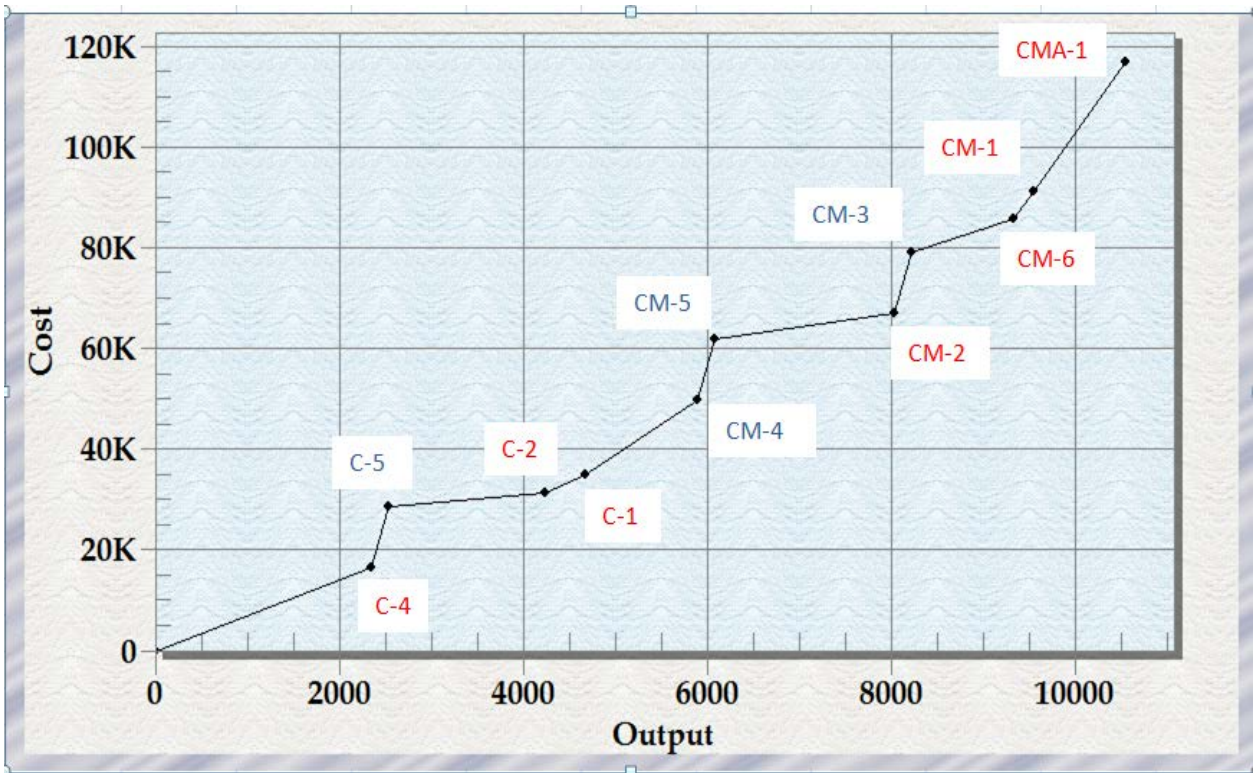

Figure 2-11: CE/ICA analysis using updated annualized costs and benefits.

2.9 Update of the NER TSP

The relative ranking of alternatives to one another as expressed in the first IWR runs was altered with the updated set of outputs. Plan A did not perform as a cost efficient plan in the refined IWR runs despite continuing to demonstrate the potential to deliver a relatively significant magnitude of benefits (975 AAHU's).

Alternative Plan CM-4, although not a Best Buy plan in the refined IWR run, is the first cost-effective plan that is comprehensive (covers both the Calcasieu/Sabine and Mermentau/Teche-Vermilion basins). Based on the data presented in Table 2-17 the financial investment required to select the first comprehensive Best Buy plan, CM-2, represents an additional cost of over $400M. Additionally, in direct comparison with the Best Buy plan CM-2, CM-4 produces 73.4 percent of those benefits at 74.0 percent of the cost. This proportionality demonstrates that the two plans are virtually identical in efficiency. For these reasons, the PDT maintains that the lower cost plan, Plan CM-4 is the TSP.

Description of the NER TSP:

- **Marsh Restoration.** Nine marsh restoration and nourishment features consist of delivering sediments to former marsh areas and eroding marsh areas (minimum of 100 acres efficiency criteria) that have water levels of less than two feet and that have been optimized to preserve or restore critical geomorphologic features to restore vegetated wetlands. This involves excavation of significant quantities and delivery of borrow material to restoration sites through designated corridors. Some restoration sites may require containment to hold sediments in place. Details for each of the restoration sites and their borrow source can be found in Appendix A and Appendix K. The marsh restoration locations include: (a) three areas on the south side of LA-82 approximately 4.5 miles west of Grand Chenier; (b) Pecan Island west of the Freshwater Bayou Canal approximately 5 miles north of the Freshwater Bayou locks; (c) Christian Marsh located east of Freshwater Bayou Canal and approximately 5 miles north of Freshwater Bayou locks; (d) southern shoreline of GIWW west of the CSC near Black Lake; (e) eastern rim of Calcasieu Lake within the Cameron-Creole Watershed; (f) east of Mud Lake and north of Highway 82; (g) Mud Lake west of Calcasieu Ship Channel adjacent to southern rim of West Cove. Dredged material sources would be the CSC and the Gulf of Mexico.
  A table summarizing details of these features is included at Table 2-18a. Construction of marsh restoration would typically involve placement of dedicated borrow material by hydraulic dredging. Placement would generally involve over placement of material to achieve a typical marsh elevation of approximately +1.5 feet NAVD88 (or as dictated by adjacent marsh elevation) following post construction settlement. As necessary earthen containment dikes would be employed to efficiently achieve the desired initial construction elevation. Dikes would be breached following construction to allow dewatering and settlement to the final target marsh elevation. All marsh restoration locations would have one future re-nourishment cycle. Subsequent marsh renourishment would employ similar techniques and specifications as developed for the initial construction. For a detailed description of each of the proposed marsh restoration projects see Appendix K. See also Appendix A, Annex V for information concerning corresponding marsh restoration project borrow sources.
- **Shoreline Protection/Stabilization.** The five Gulf shoreline protection/stabilization features span approximately 252,000 linear ft and would be used to reduce erosion of canal banks and shorelines in critical areas in order to protect adjacent wetlands and critical geomorphic features. Multiple locations of Gulf of Mexico shoreline from the Calcasieu River to Freshwater Bayou consist of reef breakwaters with lightweight aggregate core would be located approximately 150' offshore with geotextile fabric and stone built to an 18 ft crest width. In addition, approximately 13.4 miles of rock revetment built to +3 feet NAVD88 with a 4 ft crown would be placed at three locations to fortify spoil banks of the GIWW and Freshwater Bayou. Two future maintenance lifts would be required. Rock and breakwaters would also be placed at Holly Beach as a continuation of existing breakwaters; two future maintenance lifts would be required. Details of these features are included in Table 2-18b.

- **Hydrologic and Salinity Control.** The hydrologic and salinity control feature is the Cameron-Creole Spillway structure south of Lambert Bayou. It would serve as a drainage manifold and the outfall channel into Calcasieu Lake would be rock-lined for scour protection and built to +2 ft. This feature would regulate the flow of water in certain areas and inhibit salinity intrusion above a certain threshold. The Master Plan model used to evaluate hydro/salinity measure #74a needs additional refinement to properly evaluate the benefits over the 6,651-acre area of influence. The modeling indicated a slight decrease in acreage under the FWP condition (0.8 % reduction), but indicated a positive benefit in habitat quality (267 AAHU). Therefore it would be prudent to examine this measure in more detail as the study progresses. Since the net benefit is an overall increase in habitat quality, no mitigation is proposed at this time, until more detailed modeling can be conducted. Details of this feature are included in Table 2-18c.
- **Chenier Reforestation.** Chenier restoration consists of replanting of 435 seedlings per acre at 10' x 10' spacing, in 35 Chenier locations on 1,400 acres in Cameron and Vermilion parishes. Invasive species control and eradication are also included. Details of these features are included in Table 2-18d.
- The **CSC Salinity Barrier Navigation Study** is recommended as an additional long-range study feature to adequately account for potential environmental benefits, navigation impacts, and engineering.
- The NER plan first construction cost estimate is $987,738,000.

2.10 NER TSP Feature Details

Table 2-18a. Details of the marsh restoration features of the TSP (See Appendix K for fact sheets and maps detailing each NER TSP marsh restoration feature. See also Appendix A, Annex V for corresponding maps illustrating proposed borrow locations).

Measure Number	Measure Name	Basin	Marsh Type	Acres Created	Acres Nourished	Total Acres	Net Benefits (acres)	Benefits (AAHU)	Borrow Volume (cy)	Borrow Area (acres)	Borrow Renourishment Volume (cy)
3a1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	Calcasieu	Brackish	599	-	599	454	191	5,339,286	139	1,000,000
3c1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	Calcasieu	Brackish	1,765	450	2,215	1,451	654	10,199,098	314	5,600,000
47a1	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	933	88	1,021	895	272	3,022,782	1,716	1,500,000
47a2	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	1,297	126	1,423	1,218	381	8,831,084	1,716	1,500,000
47c1	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	1,304	4	1,308	1,135	353	8,557,120	1,716	1,800,000
124c	Marsh Creation at Mud Lake	Calcasieu	Saline	1,908	734	2,642	1,915	740	11,129,437	531	4,700,000
124d	Marsh Creation at Mud Lake	Calcasieu	Brackish	159	448	607	168	4	1,420,943	378	1,200,000
127c3	Marsh Restoration at Pecan Island	Mermentau	Brackish	832	62	894	735	241	7,301,057	3,950	781,000
306a1	Rainey Marsh Restoration Southwest Portion (Christian Marsh)	Mermentau	Brackish	627	1,269	1,896	743	645	8,128,181	3,950	3,500,000

(Table 2-18a continued)

Measure Number	Measure Name	State Water Bottoms (permanent) impact	Floatation Footprint (acres)	Disposal Footprint (acres)	Dike Footprint (feet)	Dike Footprint (acres)	State Water Bottoms (temporary impact)	Dredge Pipeline Route (ft)	Dredge Pipeline Route (acres)	Piping Plover Critical Habitat (acres)
3a1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	139	132	0	44,700	30.8	0	43,942	30	0
3c1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	314	182	0	92,500	63.7	0	61,497	42	0
47a1	Marsh Restoration Using Dredged Material South of Highway 82	1,716	47	0	68,300	47.0	0	35,519	24	0.14
47a2	Marsh Restoration Using Dredged Material South of Highway 82	1,716	47	0	41,000	28.2	0	30,898	21	0.14
47c1	Marsh Restoration Using Dredged Material South of Highway 82	1,716	47	0	35,200	24.2	0	29,858	21	0.14
124c	Marsh Creation at Mud Lake	531	30	0	52,600	36.2	0	10,836	7	0.34
124d	Marsh Creation at Mud Lake	314	182	0	32,500	22.4	0	21,452	15	0
127c3	Marsh Restoration at Pecan Island	3,950	110	0	46,000	31.7	0	37,074	26	0
306a1	Rainey Marsh Restoration Southwest Portion (Christian Marsh)	3,950	178	0	108,000	74.4	0	59,731	41	0

Table 2-18b. Details of the shoreline protection features of the TSP (See Appendix K for fact sheets and maps detailing each NER TSP shoreline protection feature).

Measure Number	Measure Name	Basin	Marsh Type	Net Benefits (acres)	Benefits (AAHU)	Shoreline Feature Length (ft)	Rock (tons)	Grade Rock (lbs)	Geotextile Fabric (sq yds)	Lightweight Aggregate (tons)	1st Maintenance Lift (tons)	2nd Maintenance Lift (tons)
5a	Holly Beach Shoreline Stabilization – Breakwaters	Calcasieu	Saline	26	56	46,014	860,540	250	386,460	0	129,081	86,054
6b1	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	2140	625	58,293	868,480	250	447,830	479,150	86,848	0
6b2	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	1583	466	42,883	687,140	250	363,270	357,010	68,714	0
6b3	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	1098	312	33,355	561,530	250	244,205	279,030	56,153	0
16b	Fortify Spoil Banks of the GIWW and Freshwater Bayou	Mermentau	Brackish	662	156	70,983	617,640	250	516,860	0	92,646	61,764

(Table 2-18b continued)

Measure Number	Measure Name	State Water Bottoms (permanent)	Breakwater Footprint	Floatation Footprint (acres)	Disposal Footprint (acres)	State Water Bottoms (temporary)	Critical Habitat (acres)	Staging Area (acres)	Crown Elevation (feet NAVD88)	Crown Width (feet)	Slopes	Aprons
5a	Holly Beach Shoreline Stabilization – Breakwaters	57.4	57.4	479	462	941	0	0	3.50	24	2:1	10-ft front & 6-ft back
6b1	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	65.9	65.9	725	711	1436	0	21	3.25	18	2:1	10-ft front & 6-ft back
6b2	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	40.2	40.2	507	497	1004	0	21	3.25	18	2:1	10-ft front & 6-ft back
6b3	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	37.8	37.8	372	289	661	0	21	3.25	18	2:1	10-ft front & 6-ft back
16b	Fortify Spoil Banks of the GIWW and Freshwater Bayou	77.1	77.1	358	0	0	0	0	3.00	4	4:1	none

Table 2-18c. Details of the hydrologic & salinity control feature of the TSP (see Appendix K for fact sheet and map detailing the NER TSP hydrologic and salinity control feature).

Measure Number	Measure Name	Basin	Marsh Type	Net Benefits (acres)	Benefits (AAHU)	Area of Influence (acres)	Rock (tons)	Grade Rock (lbs)	Geotextile Fabric (sq yds)	Floatation Footprint (acres)	Disposal Footprint (acres)	State Water Bottoms (Permanent)	State Water Bottoms (Temporary)	Critical Habitat (acres)	Staging Area (acres)
74a	Cameron Spillway Structure at East Calcasieu Lake	Calcasieu	Brackish	-56*	267*	6,651	47,800	250	13,600	104	104	3	104	0	0

* The Master Plan model used to evaluate hydro/salinity measure #74a needs additional refinement to properly evaluate the benefits over the 6,651-acre area of influence.

Table 2-18d. Details of the chenier reforestation features of the TSP (see Appendix K for fact sheets and maps detailing the NER TSP chenier reforestation features).

Measure Number	Measure Name	Net Benefits (acres)	Benefits (AAHU)	Species	Total Fence Length (feet)	Fence Height (feet)	Planting Density (#/acre)	Spacing (feet)	Survival (percent)	Equipment Access Corridor (feet)	Equipment Access Corridor (acres)	State Water Bottoms (permanent)	State Water Bottoms (temporary)	Critical Habitat (acres)	Staging Area (acres)
CR (total)	Chenier Reforestation	1,413	538	Live Oak; Hackberry	150,000	7.5	435	10 x 10	57%	13,867	10	0	0	0	0

2.11 Views of the Non-Federal Sponsor

CPRAB recognizes the importance of hurricane and storm surge risk reduction and ecosystem restoration in the study area as evidenced by the fact that the 2012 State Master Plan includes this study. Implementation of the NED Plan would provide hurricane and storm surge risk reduction to eligible properties within the study area. The NER Plan would help to restore, and protect the critical Chenier Plain providing multiple environmental benefits to southwest coastal Louisiana. CPRAB and numerous local stakeholders participated with CEMVN in the PDT process and have given input to develop the various measures and alternatives to formulate the plans. CPRAB currently has expressed no objection to the features of the NER and NED plans, and both plans are consistent with the State Master Plan. However, CPRAB continues to support construction of structural risk reduction features like levees across the study area as the most efficient way to reduce flood damage risks to residents of the study area.